**Russian-German Cooperation SYSTEM LAPTEV SEA:**

# The Expedition Lena- 2005


*by the participants of the expedition*

*edited by Lutz Schirrmeister and Dirk Wagner,*

*Mikhail N. Grigoriev, Dimitry Yu. Bolshiyanov*


# Contents

# 1. Introduction

*Lutz Schirrmeister and Mikhail N. Grigoriev*

The purpose of the expedition LENA 2005 was to fill gaps of knowledge and to answer scientific questions that arose during former expeditions. Additionally, the monitoring program based at Samoylov Island was continued and expanded.

Scientific investigations were focused on the following topics:

A. Permafrost soils and ecosystems (● Chapter 3: *Microbiological processes, trace gas fluxes and hydrobiology in permafrost ecosystems of the Lena Delta)*

B. Periglacial landscape dynamics (● *Chapter 4: Studies of periglacial landscape dynamics and surface characteristics studies in the western Lena Delta)*

C. Ground ice as climate archive (● *Chapter 5: Holocene ice wedges of the 1st Lena terrace)*

D. Modern delta hydrology (● *Chapter 6: Report of the hydrological work in the Lena River Delta in August 2005)*


## *Acknowledgements*

The success of the expedition LENA 2005 would not have been possible without the support by several Russian, Yakutian, and German institutions and authorities. In particular, we would like to express our appreciation to the Tiksi Hydrobase and the Lena Delta Reserve, special thanks to D. Melnichenko and A. Gukov. The members of the expedition wish to thank the captains and crewmembers of the vessel “Neptun” and the staff of the Lena Delta Reserve station on Samoylov Island.

The LENA 2005 expedition was a contribution to the joint research project “Process studies of permafrost dynamics in the Laptev Sea” (project number 03G0589) founded by he German federal ministry of Education and Research (BMBF) as well as to the Russian German Science cooperation “SYSTEM LAPTEV SEA”:

## 2. Expedition itinerary and general logistics

*Lutz Schirrmeister and Mikhail N. Grigoriev*

Four research teams (Table 2-1) were formed to conduct the planned scientific tasks.

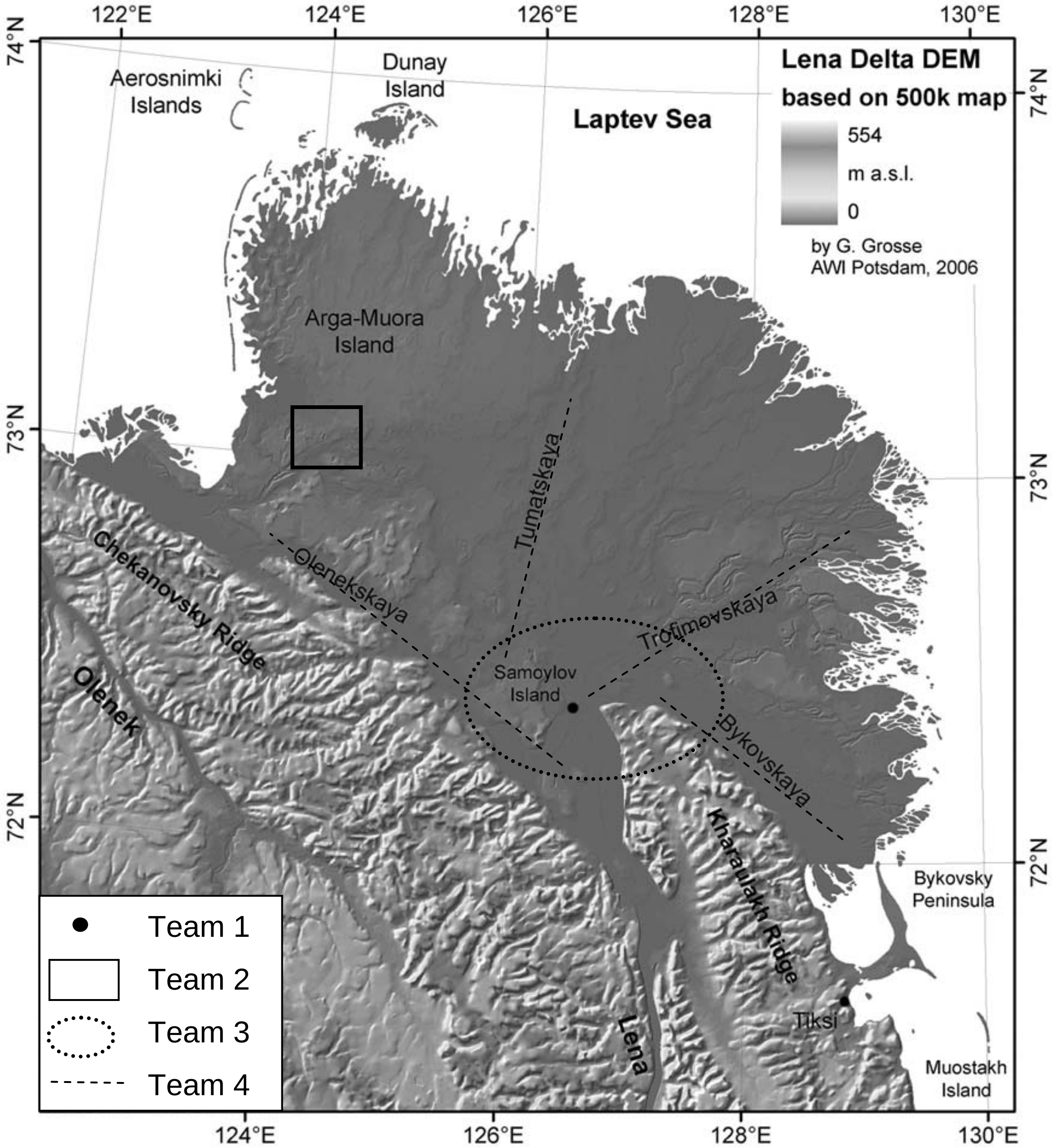


**Figure 2-1:** Study sites and itineraries during the expedition Lena-2005.

**Team 1** was based at the biological station of the Lena Delta Reserve on Samoylov Island in the central Lena Delta from July 11 through September 5, 2005. This team was split into two groups of 8 and 10 persons and focused on:

- The characterisation of the structure and function of microbial communities taking part in the carbon budget in permafrost soils;
- The understanding of modern processes in permafrost soils (energy and water balance, methane fluxes);

- Studies of plankton formation in lakes of the central Lena Delta.

- ***Chapter 3: Trace gas fluxes and ecological studies in permafrost environments of the Central Lena Delta***

**Team 2** consisted of 9 persons and was based at a field camp on Ebe Basyn Sise Island at the Arynskaya River Channel in the western Lena Delta from August, 14 to September, 1. This group was transferred to the camp-site by the river vessel "Neptun" and back to Tiksi by helicopter. It worked on several surrounding islands (Turakh Sise, Ebe Basyn Sise, Khardang), which were reached with a Zodiac boat. Team 2 focused on:

- Geological relations of Quaternary sequences of the "Arga-Complex" and of Khardang Island;
- Surface characteristics of periglacial landforms
- Dynamics of thermokarst lakes on the 2$^{nd}$ Lena Delta terrace.

- ***Chapter 4: Periglacial landscape dynamics and surface characteristics studies in the western Lena Delta***

**Team 3** worked on Samoylov Island and along the main channels of the Central Lena Delta (Bykovskaya, Trofimovskaya, Tumatskaya, Olenekskaya, Arynskaya). This small team of two persons was based on Samoylov Island and reached study sites using a motorboat and the vessel "Neptun". The main focus of this group was to provide a:

- Better understanding of the genesis of the 1$^{st}$ Lena Delta terrace with a special focus on Holocene ice wedges

- ***Chapter 5: Holocene ice wedges of the 1st Lena terrace***

**Team 4** consisted of 4 people collecting hydrological data of water discharge and sediment transport of several major channels of the Lena Delta. These studies were carried out on board of the river vessel "Neptun" as well as by several motorboats trips. The main objective of this group was to undertake:

- Palaeo-geographical and hydrological studies in the central Lena Delta.

- ***Chapter 6: Hydrological and geomorphological studies of the modern Lena Delta***

The general logistics of the LENA 2006 Expedition were jointly organized by the Permafrost Institute (Yakutsk), the Arctic and Antarctic Research Institute (St. Petersburg) and the Research Unit Potsdam of the Alfred Wegener Institute. Logistic operations in Tiksi (rental of buses, trucks, vessels, helicopters etc.) were organized by the Tiksi Hydrobase.

The list of participants and the addresses of the institutions involved are presented in Table 2-1 and Table 2-2.

**Table 2-1.** List of participants.

| Name | email | Institution | Team |
|---|---|---|---|
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| Dimitry Bolshiyanov | bolshiyanov@aari.nw.ru | AARI | 4 |
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| Mikhail Grigoriev | grigoriev@mpi.ysn.ru | PIY | 2 |
| Guido Grosse | ggrosse@awi-potsdam.de | AWI | 2 |
| Susanne Kopelke | s.kopelke@ifb.uni-hamburg.de | IfB | 1 |
| Victor Kunitsky | kunitsky@mpi.ysn.ru | PIY | 2 |
| Tatyana Kuznetsova | esin@sgm.ru | MGU | 2 |
| Hugues Lantuit | hlantuit@awi-potsdam.de | AWI | 2 |
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| Mathias Ulrich | ulmat@web.de | AWI, UL | 2 |
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| Christian Wille | cwille@awi-potsdam.de | AWI | 1 |

**Table 2-2.** List of participating institutions.

| | |
|---|---|
| **AARI** | Arctic and Antarctic Research Institute<br>Bering St. 38, 199397 St. Petersburg, Russia |
| **SpSU** | Sankt Petersburg State University, Faculty of Geography and Geo-ecology, Dept. of Hydrology; 33, 10th Line (Island Vasil'evskiy) St. Petersburg, 199178, Russia |
| **LDR** | Lena Delta Reserve<br>28 Academician Fyodorov St., Tiksi 678400, Yakutia, Russia |
| **MGU** | Moscow State University, Faculty of Paleontology<br>119899 Moscow, Russia |
| **PIY** | Permafrost Institute, Russian Academy of Science<br>677018 Yakutsk, Yakutia, Russia |
| **UL** | University Leipzig; Institute for Geography, Johannisallee 19a, 04109 Leipzig, Germany |
| **AWI** | Alfred Wegener Institute, Research Unit Potsdam<br>PO Box 60 0149, D-14401 Potsdam, Germany |
| **IFB** | Institute for Soil Science, Hamburg University<br>Allende-Platz 2, D-20146 Hamburg, Germany |

# 3 Microbiological processes, trace gas fluxes and hydrobiology in permafrost ecosystems of the Lena Delta

## 3.1 Introduction

*Dirk Wagner, Susanne Liebner and Eva-Maria Pfeiffer*

Northern wetlands such as the Lena Delta in north-east Siberia are significant natural sources of methane (Friborg *et al.* 2003; Smith *et al.* 2004; Corradi *et al.* 2005) and other climate relevant trace gases. As a consequence of the harsh winter climate, decomposition processes in northern wetlands are inhibited leading to an accumulation of organic matter. The organic matter is partly decomposed under water-saturated, anaerobic conditions during the short summer period. The terminal step in the anaerobic decomposition of organic matter is the microbial formation of methane (methanogenesis). Several studies estimated the methane source strength of northern wetlands, including tundra, to range from 17 to 42 Tg $CH_4$ $yr^{-1}$ (Whalen and Reeburgh 1992, Cao *et al.* 1996, Joabsson and Christensen 2001, Wagner *et al.* 2003). This corresponds to about 25 % of the methane release from natural sources (Fung *et al.* 1991).

Global warming could thaw 25 % of the permafrost area by 2100 (Anisomov *et al.* 1999) exposing huge amounts of currently fixed organic carbon to aerobic as well as anaerobic decomposition processes. Also, higher temperatures are likely to reinforce methanogenesis and therefore increase the methane source strength of Arctic wetlands (Wuebbles & Hayhoe 2002). Additional methane would have a positive feedback on the atmospheric warming process because methane is both on a mass and a molecule level 23 times more effective as a greenhouse gas than $CO_2$ (IPCC 2001).

The biological oxidation of methane by methane oxidising (methanotrophic) bacteria, which belong to the $\alpha$- (type II methanotrophs) and $\gamma$- (type I methanotrophs) *Proteobacteria*, is the major sink for methane in terrestrial habitats. Between 43 and 90% of the methane produced in the soil is oxidised before reaching the atmosphere (Le Mer & Roger 2001, Roslev & King 1996). Hence, it is crucial to investigate methanotrophic communities and their response to global change in particular in climatic sensitive regions like the Lena Delta.

The nitrogen turnover is strongly correlated with the carbon cycle but little is known about nitrogen fluxes in Arctic ecosystems and the responsible organisms. Nitrifying bacteria were detected in old deep permafrost sediments, where they can survive long periods of starvation and dryness (Soina et al. 1991, Bartosch et al. 2002). Nearly nothing is known about the Arctic source strength for the long-life greenhouse gases NO and $N_2O$. Furthermore, the interaction of climate relevant processes like microbial $CH_4$ oxidation is influenced by the activity of ammonia oxidizers. The Artic carbon fluxes and turnover times are limited by the microbially mediated nitrogen mineralization.

Based on the experience and results of almost one decade of successful research in the Lena Delta region, the main focus of the eighth expedition was on trace gas flux measurements ($CH_4$, $CO_2$), to gain more insights into the relationships of structure and function of microbial communities involved in carbon decomposition and on the dynamic of zooplankton in the thermokarst lakes.

## 3.2 Dynamic of methane oxidising communities in permafrost soils

*Susanne Liebner and Dirk Wagner*

### 3.2.1 Introduction

Methane oxidation by obligately aerobic methane oxidising (methanotrophic) bacteria is the main sink for the greenhouse gas methane in terrestrial habitats. Our study investigates how the warming of the Russian tundra could alter methane fluxes by altering the methanotrophic community. In particular, we aim at investigating adaptation, phylogeny and dynamic of the methane oxidising community in 'active layer' samples from Samoylov Island.

### 3.2.2 Sampling procedure and field parameters

For the purpose of an investigation of the temporal and spatial dynamic of the methanotrophic community, active layer cores of a polygon rim, transition and a polygon center were sampled frequently at intervals of 3-4 days between July, 15$^{th}$ and September 1$^{st}$ 2005 (Figure 3-1). Active layer cores are listed in Table 3-1.

The sampling of the active layer cores was accompanied by measuring depth of the permafrost table, water level, water content and soil temperature. All parameters are summarized in Table 3-2. In addition, the pore water methane concentration of polygon rim, transition, and polygon center was determined (chapter 3.2.3). Beside the active layer cores, fresh soil samples of polygon rim and transition were taken for the determination of soil physical and chemical properties (Table 3-3).

**Figure 3-1:** Sampling of active layer cores within a low-centred polygon (N 72°22, E 126°28): Steel cores (l=50 cm, Ø=50 mm) were turned into the 'active layer', undisturbed cores were sampled, stored in plastic foil and frozen immediately after sampling for molecular processing in the lab.

### 3.2.3 Pore water methane concentration

Measurements of porewater methane concentration were carried out by placing fresh soil samples together with a saturated NaCl solution into glass jars. After intensive shaking of the closed jars, methane was forced from the soil solution into the headspace of the bottles and was analysed by gas chromatography. Methane concentrations are shown in Figure 3-2.

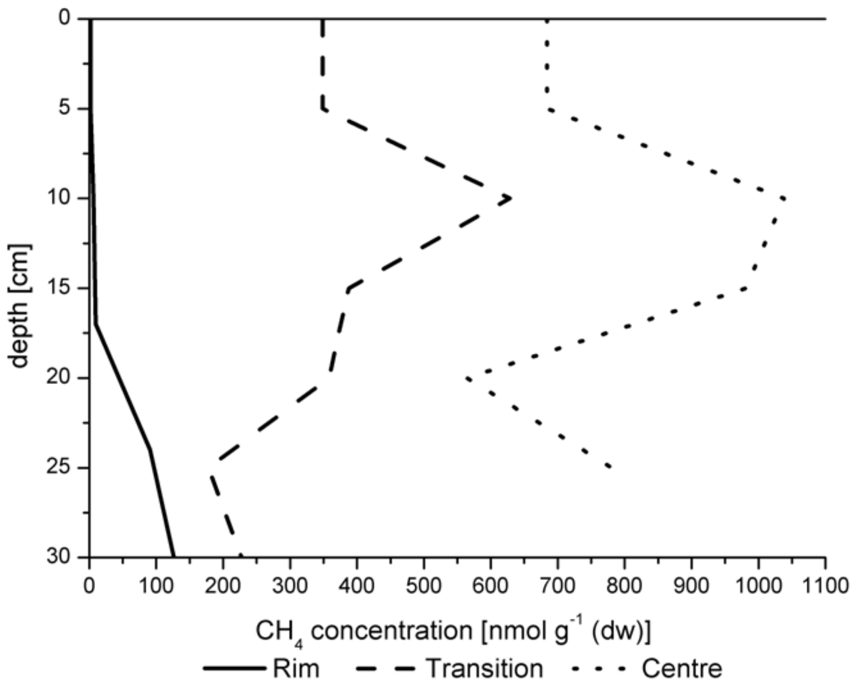


**Figure 3-2:** Methane concentration within a low-centred polygon (N 72°22, E 126°28). Date of measurement: 04.08.2005.

**Table 3-1:** List of active layer cores (length: 50 cm, Ø 50 mm, Box: 0285) of a low-centred polygon on Samoylov Island (N 72°22.2', E 126°28.5'), sampling period: July 15th to September 1st 2005.

| Core ID | Core No | Description | Date |
|---|---|---|---|
| LD05 | AC_1 | Rim | 15.07.2005 |
| LD05 | AC_2 | Rim | 15.07.2005 |
| LD05 | AC_3 | Rim | 15.07.2005 |
| LD05 | AC_4 | Transition | 15.07.2005 |
| LD05 | AC_5 | Transition | 15.07.2005 |
| LD05 | AC_6 | Centre | 15.07.2005 |
| LD05 | AC_7 | Centre | 15.07.2005 |
| LD05 | AC_8 | Rim | 18.07.2005 |
| LD05 | AC_9 | Transition | 18.07.2005 |
| LD05 | AC_10 | Centre | 18.07.2005 |
| LD05 | AC_11 | Rim | 21.07.2005 |
| LD05 | AC_12 | Transition | 21.07.2005 |
| LD05 | AC_13 | Centre | 21.07.2005 |
| LD05 | AC_14 | Rim | 25.07.2005 |
| LD05 | AC_15 | Transition | 25.07.2005 |
| LD05 | AC_16 | Centre | 25.07.2005 |
| LD05 | AC_17 | Rim | 28.07.2005 |
| LD05 | AC_18 | Transition | 28.07.2005 |
| LD05 | AC_19 | Centre | 28.07.2005 |
| LD05 | AC_20 | Rim | 01.08.2005 |
| LD05 | AC_21 | Rim | 01.08.2005 |
| LD05 | AC_22 | Transition | 01.08.2005 |

**Table 3-1: continued:** List of active layer cores (length: 50 cm, Ø 50 mm, Box: 0285) of a low-centred polygon on Samoylov Island (N 72°22, E 126°28), sampling period: July 15th to September 1st 2005.

| Core ID | Core No | Description | Date |
|---|---|---|---|
| LD05 | AC_23 | Centre | 01.08.2005 |
| LD05 | AC_24 | Rim | 04.08.2005 |
| LD05 | AC_25 | Transition | 04.08.2005 |
| LD05 | AC_26 | Centre | 04.08.2005 |
| LD05 | AC_27 | Rim | 11.08.2005 |
| LD05 | AC_28 | Transition | 11.08.2005 |
| LD059 | AC_29 | Centre | 11.08.2005 |
| LD05 | AC_30 | Rim | 18.08.2005 |
| LD05 | AC_31 | Transition | 18.08.2005 |
| LD05 | AC_32 | Centre | 18.08.2005 |
| LD05 | AC_33 | Rim | 25.08.2005 |
| LD05 | AC_34 | Transition | 25.08.2005 |
| LD05 | AC_35 | Centre | 25.08.2005 |
| LD05 | AC_36 | Rim | 01.09.2005 |
| LD05 | AC_37 | Transition | 01.09.2005 |
| LD05 | AC_38 | Centre | 01.09.2005 |

**Table 3-2:** List of soil samples (Nalgene boxes) of a low-centred polygon on Samoylov Island (N 72°22, E 126°28), date of sampling: July 07th 2005.

| Sample ID | Sample No | Description of soil horizons | Depth [cm] | Amount [ml] | Date |
|---|---|---|---|---|---|
| LD05 | 7190 | A/O (rim) | 0-6 | 750 | 18.07.05 |
| LD05 | 7191 | Bg (rim) | 6-13 | 750 | 18.07.05 |
| LD05 | 7192 | Bg/Go (rim) | 13-20 | 750 | 18.07.05 |
| LD05 | 7193 | Bg (rim) | 20-27 | 750 | 18.07.05 |
| LD05 | 7194 | Bg/P (rim) | 27-35 | 750 | 18.07.05 |
| LD05 | 7195 | A/O (transistion) | 0-9 | 750 | 18.07.05 |
| LD05 | 7196 | Bg (transition) | 9-15 | 750 | 18.07.05 |
| LD05 | 7197 | Bg (transition) | 15-21 | 750 | 18.07.05 |
| LD05 | 7198 | Bg/P (transition) | 21-25 | 750 | 18.07.05 |

**Table 3-3:** Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

| Date | Active layer depth [cm] | | | Water level* [cm] | | Water content* [%] | | Soil temperature [°C] | | | Depth [cm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | rim | trans | centre | rim | trans | rim | trans | rim | trans | centre | |
| | | | | | | | | 4.5 | 8.3 | 9.4 | 5 |
| | | | | | | | | 3.5 | 6.5 | 6.9 | 10 |
| | | | | | | | | 2.7 | 4 | 5.8 | 15 |
| **15.7.05** | 32.7 | 29.7 | 30.7 | 17 | 2 | n.d. | | 1.8 | 2.8 | 3.9 | 20 |
| | | | | | | | | 0.8 | 1.5 | 2.4 | 25 |
| | | | | | | | | | 0.5 | 0.5 | 30 |
| | | | | | | | | | | | 35 |

**Table 3-3 continued:** Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

| Date | Active layer depth [cm] | | | Water level* [cm] | | Water content* [%] | | Soil temperature [°C] | | | Depth [cm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | rim | trans | centre | rim | trans | rim | trans | rim | trans | centre | |
| | | | | | | | | 8.9 | 11.3 | 14.8 | 5 |
| | | | | | | | | 7.2 | 8.9 | 10.2 | 10 |
| | | | | | | | | 5.4 | 5.7 | 7.7 | 15 |
| **18.07.05** | 33.7 | 31.3 | 32 | 17 | 4 | n.d. | | 4.2 | 3.8 | 5.6 | 20 |
| | | | | | | | | 2.7 | 2. | 3.5 | 25 |
| | | | | | | | | 1.3 | 0.4 | 1.9 | 30 |
| | | | | | | | | 0.2 | | 0.5 | 35 |
| | | | | | | | | 8.1 | 8.8 | 12.7 | 5 |
| | | | | | | | | 7.5 | 8.2 | 10.4 | 10 |
| | | | | | | | | 6.3 | 6.8 | 6.3 | 15 |
| **21.07.05** | 35.7 | 34 | 33 | 16 | 4 | n.d. | | 5.3 | 5.4 | 3.8 | 20 |
| | | | | | | | | 3.5 | 3.9 | 1.3 | 25 |
| | | | | | | | | 2.2 | 1.9 | | 30 |
| | | | | | | | | 0.7 | 0.4 | | 35 |
| | | | | | | 52.6 | 31.1 | 5.3 | 6.1 | 8.2 | 5 |
| | | | | | | 63.5 | 86.1 | 4.9 | 5.5 | 7.8 | 10 |
| | | | | | | 68.1 | 87.6 | 4.3 | 4.4 | 6.9 | 15 |
| **25.07.05** | 37.3 | 33 | 34 | 17 | 4 | 100 | 100 | 3.5 | 3.4 | 5 | 20 |
| | | | | | | | | 2.7 | 2.1 | 3.5 | 25 |
| | | | | | | | | 2 | 1 | 2.1 | 30 |
| | | | | | | | | 1.1 | | 1.1 | 35 |

**Table 3-3 continued:** Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

| **Date** | **Active layer depth [cm]** | | | **Water level* [cm]** | | **Water content* [%]** | | **Soil temperature [°C]** | | | **Depth [cm]** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | rim | trans | centre | rim | trans | rim | trans | rim | trans | centre | |
| | | | | | | 56.3 | 32 | 4 | 5.5 | 6.7 | 5 |
| | | | | | | 67.8 | 87.6 | 3.7 | 5. | 6.2 | 10 |
| | | | | | | 73.1 | 87.6 | 3.3 | 3.7 | 5 | 15 |
| **28.07.05** | 38.7 | 35 | 35 | 18 | 6 | 100 | 100 | 2.7 | 3 | 3.9 | 20 |
| | | | | | | | | 2.1 | 2.1 | 2.9 | 25 |
| | | | | | | | | 1.7 | 1.2 | 1.9 | 30 |
| | | | | | | | | 1.3 | 0.4 | 0.9 | 35 |
| | | | | | | 65.2 | 36.9 | 6.3 | 6.5 | 0.4 | 5 |
| | | | | | | 71.5 | 87.6 | 5.7 | 6.3 | 8.4 | 10 |
| | | | | | | 77.6 | 87.6 | 5.3 | 5.3 | 7.8 | 15 |
| **01.08.05** | 40.3 | 37 | 37 | 16 | 4 | 100 | 100 | 4.7 | 4.4 | 6.7 | 20 |
| | | | | | | | | 3.4 | 3.2 | 5.3 | 25 |
| | | | | | | | | 2.6 | 1.9 | 3.6 | 30 |
| | | | | | | | | 1.8 | 1 | 2.7 | 35 |
| | | | | | | 81.7 | 48.9 | 5.4 | 6 | 7 | 5 |
| | | | | | | 87.6 | 100 | 4.8 | 5.2 | 6.1 | 10 |
| | | | | | | 100 | 100 | 4.3 | 4.1 | 5.1 | 15 |
| **04.08.05** | 41.7 | 36.7 | 37 | 16 | 4 | 100 | 100 | 3.6 | 3.2 | 3.7 | 20 |
| | | | | | | | | 2.7 | 2.3 | 2.8 | 25 |
| | | | | | | | | 2.1 | 1.5 | 1.8 | 30 |
| | | | | | | | | 1.6 | 0.7 | 0.9 | 35 |

**Table 3-3 continued:** Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 5.2 | 7.1 | 11.8 | 5 |
| | | | | | | | | 4.4 | 5.1 | 11.7 | 10 |
| | | | | | | | | 3.6 | 3.5 | 8.9 | 15 |
| **18.08.05** | 45.7 | 36 | 45.5 | 13.5 | 2 | n.d. | | 3 | 2.9 | 7.1 | 20 |
| | | | | | | | | 2.5 | 2.3 | 5.6 | 25 |
| | | | | | | | | 2 | 1.6 | 5.1 | 30 |
| | | | | | | | | 1.6 | 0.9 | 3.9 | 35 |
| | | | | | | n.d. | n.d. | 3.3 | 4.6 | 4.2 | 5 |
| | | | | | | 60.2 | 46.8 | 2.8 | 3.6 | 3.6 | 10 |
| | | | | | | 75.7 | 87.6 | 2.6 | 2.7 | 3 | 15 |
| **25.08.05** | 47.3 | 39 | 37.3 | 13 | 1 | 81.3 | 100 | 2.2 | 2 | 2.4 | 20 |
| | | | | | | | | 1.9 | 1.7 | 1.9 | 25 |
| | | | | | | | | 1.7 | 1.3 | 0.9 | 30 |
| | | | | | | | | 1.4 | 0.8 | | 35 |
| | | | | | | n.d. | n.d. | 2.3 | 2.3 | 3.4 | 5 |
| | | | | | | 58.9 | 57.1 | 2.2 | 2.1 | 2.7 | 10 |
| | | | | | | 72.3 | 100 | 2.1 | 2 | 2 | 15 |
| **01.09.05** | 48 | 40.7 | 36.3 | 10 | 0 | 74.1 | 100 | 1.9 | 1.9 | 1.5 | 20 |
| | | | | | | | | 1.8 | 1.8 | 1 | 25 |
| | | | | | | | | 1.5 | 1.3 | 0.6 | 30 |
| | | | | | | | | 1.3 | 0.9 | 0.2 | 35 |

* water-level above surface of the polygon centre, n.d.=not detected, trans=transition

### 3.2.4 Sample processing and analyses

Active layer cores that were frequently sampled from a low-centred polygon will be further investigated on the basis of a molecular approach. Using the microbiological lab-facilities at the Alfred Wegener Institute in Potsdam, DNA as well as mRNA will be extracted from different depths of a polygon rim, a polygon centre and the transition zone. Polymerase chain reactions (PCR) will be carried out to amplify ribosomal and functional genes. These genes will be analysed in terms of phylogenetic relatedness, species diversity and the spatial and temporal dynamics within the arctic summer period. For this purpose, 16S rDNA clone libraries shall be designed supplemented by *in-situ* cell counting using fluorescence hybridization. Furthermore, molecular fingerprinting will be done using the denaturing gradient gel electrophoresis (DGGE). This will lead to a comprehensive understanding of the dynamic and diversity of the methanotrophic community within low-centred polygons on Samoylov Island.

## 3.3 Microbial studies on nitrification from permafrost environments

*Claudia Fiencke, Susanne Kopelke and Eva-Maria Pfeiffer*

### 3.3.1 Introduction

Since artic wetland soils are the most important natural source of the climate relevant trace gas methane, many investigations focused on the microbial C-cycle of permafrost soils. But despite a close connection between C-cycle and N-cycle, the N-cycle is mostly unexplored.

Nitrogen as carbon cycling in arctic ecosystems is dominated by physical and biogeochemical controls which are unique to the generally cold-dominated environment. Drastic seasonal fluctuations in temperature, a short growing season, cold soil temperature and the occurrence of permafrost are some of the obvious physical controls on nitrogen cycling and biological activity. Most of the nitrogen accumulates in the organic substance in response to low soil temperatures, excessive soil moisture and low soil oxygen concentration (Gersper et al., 1980, Marion & Black, 1987; Nadelhoffer et al., 1991, Schimel et al., 1996). Standing crop in tundra vegetation store about 2 times more nitrogen than temperate grasslands (Van Cleve & Alexander, 1981). But through the low N-mineralisation rates and lack of N-input by N-fixation and N-pollution the soils are nitrogen deficient and rely to a large extent on internally recycling (McCown, 1978).

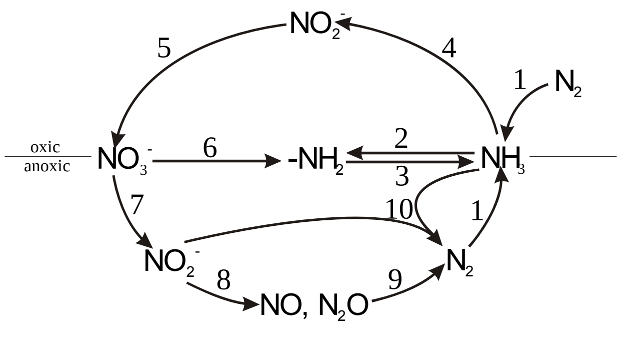


**Figure 3-3:** Nitrogen cycle. (1) Dinitrogen ($N_2$) fixation, (2) assimilation of ammonia ($NH_3$) to amino group ($-NH_2$) of protein, (3) ammonification, (4) ammonia oxidation, (5) nitrite ($NO_2^-$) oxidation, (6) assimilation of nitrate ($NO_3^-$), (7, 8, 9) denitrification via nitrite, nitric oxide (NO) and nitrous oxide ($N_2O$), (10) anaerobic ammonia oxidation.

N-cycling in the soil is crucial for growth of plants and microorganisms. Unbalances in N-cycling due nitrate leaching, nitrogen oxide release and increase the methane emission (Adamsen & King, 1993; Carini et al., 2003). Most of the N-transformations were catalyzed by microorganisms (Figure 3-3, Fiencke et al., 2005).

Nitrification, the microbiological oxidation of ammonia to nitrate via nitrite, occupies a central position within the terrestrial nitrogen cycle (Figure 3-3: step 4 and 5). Aerobic chemolithoautotrophic ammonia and nitrite oxidizing proteobacteria represent the most important group of nitrifying bacteria (Fiencke et al., 2005). As a result of nitrate and acid formation, the nitrification process has various direct and indirect implications of soil systems. It increases the loss of soil nitrogen due to leaching of nitrate and volatilization of nitrogen gases directly or by denitrification and therefore, influences the nitrogen supply to plants.

Nitrifying bacteria are found in the upper layer of soils like rhizosphere where organic matter is mineralized, and ammonia and oxygen are present. The slow growth rates and difficulties in recovering pure cultures have hampered cultivation-dependent approaches to investigate the number, community composition and dynamics of nitrifiers in soil. The number and turnover rate is therefore determined by traditionally methods like most-probable-number (MPN) technique and activity tests.

During the Expedition to the Lena Delta in summer 2005 microbial nitrification were investigated by field experiments. Furthermore soil and gas samples were taken for further ecological, molecular and soil analyses.

### 3.3.2 Field experiments: Impact of polygonal soil parameter on nitrification

*Methods: Quantification of nitrifying bacteria and activity measurements*

The investigations of nitrification were carried out on Samoylov in August 2005. Soil samples were taken from two polygons, at the polygon rim and polygon center, at 3 depths (0-5, 5-15, 15-25 cm). From the fresh samples nitrifying bacteria, ammonia and nitrite oxidizing, were enriched for further quantification by MPN-technique in media with 1 mM ammonium and 0.3 mM nitrite at about 6°C. In the same samples the ammonia oxidizing activities were measured at about 17°C. To determine the influence of time and temperature the cell numbers and activities of nitrifiers in the same samples will be later analyzed after transportation above and below 0°C in our institute in Hamburg. For the first impression of $N_2O$ emission of the soils, gas samples were taken at the same sites. The ammonia oxidizing community will be further characterized by sequencing of *amoA*.

*Preliminary results*

Although the data were not completely analyzed, first results show obvious similarities to the samples taken last year (July 2004). The chemical characterization of the soil samples shows that in the moist, anaerobic and methane containing polygon center ammonium accumulates and only low concentration of nitrite and nitrate were found (Figure 3-4a). In the dryer polygon rim high nitrate concentration were found in the oxic top soil (Figure 3-4b).

In the dryer, aerobic polygon rim high nitrate and low inhibitory methane concentrations correlated with high cell numbers and activities of ammonia oxidizing bacteria (Figure 3-5a). In contrast in the moist, anaerobic, methane containing polygon center lower cell numbers and activities of ammonia oxidizing bacteria were detected (Figure 3-5b).

The results show that small scale differences in soil hydrology have significant impact on the N-cycle. Better drained, reduced acidity and methane concentration of oxic soil samples of the polygon rim favour nitrification and therefore leads to the accumulation of nitate. Nitrate was possibly not degraded in dry sites owing to lack of denitrification in these more aerated micro-environments. Instead in the moist polygon center nitrification was inhibited by oxygen deficiency and therefore the ammonium formed by mineralization was accumulated. In the moist anoxic environment nitrate were possibly fast reduced by denitrification.

Further investigations will consider unstudied processes and fluxes in the N-cycle like mineralization and dentrification.

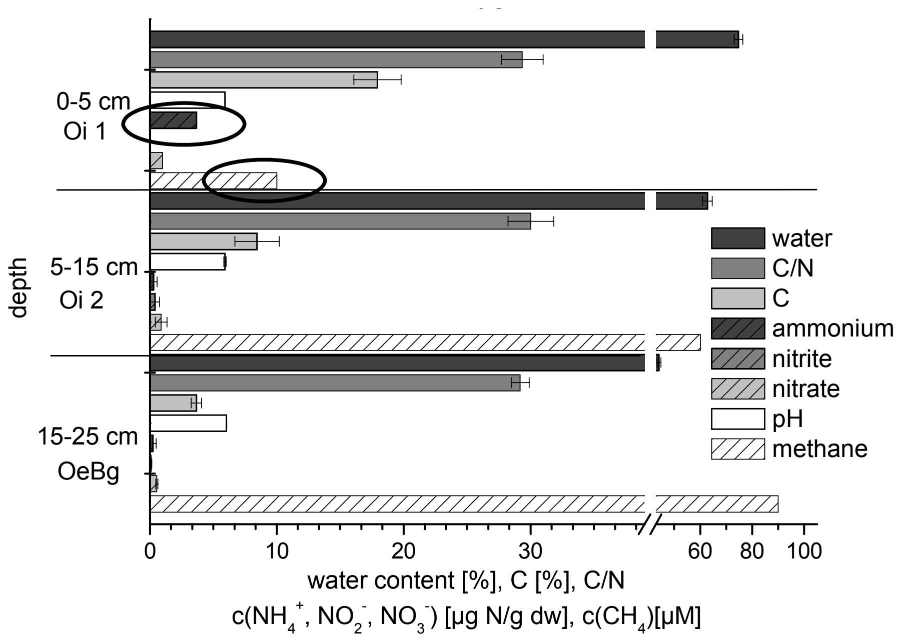


**Figure 3-4b:** Chemical soil parameters of polygon center.

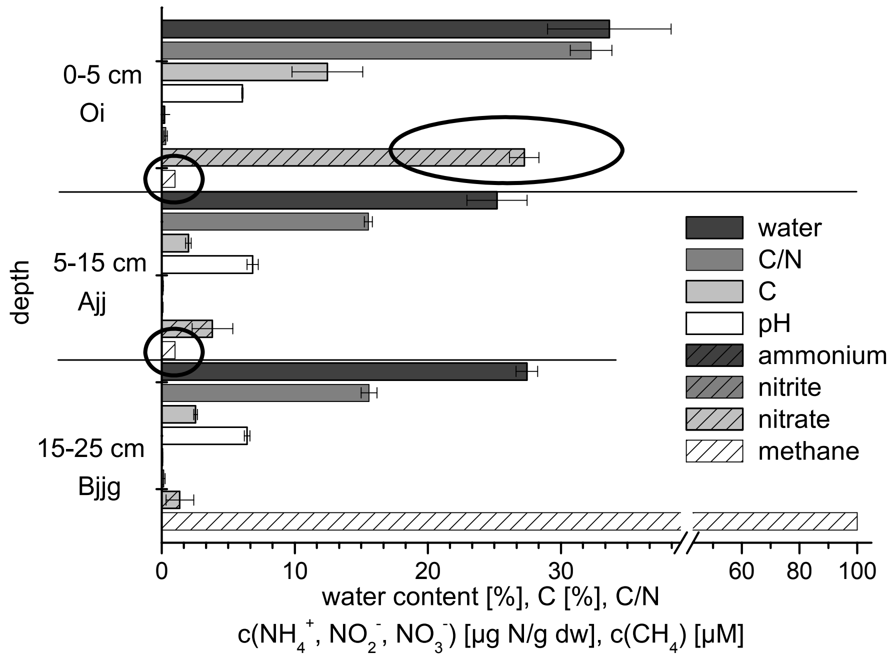


**Figure 3-4a:** Chemical soil parameters of polygon rim.

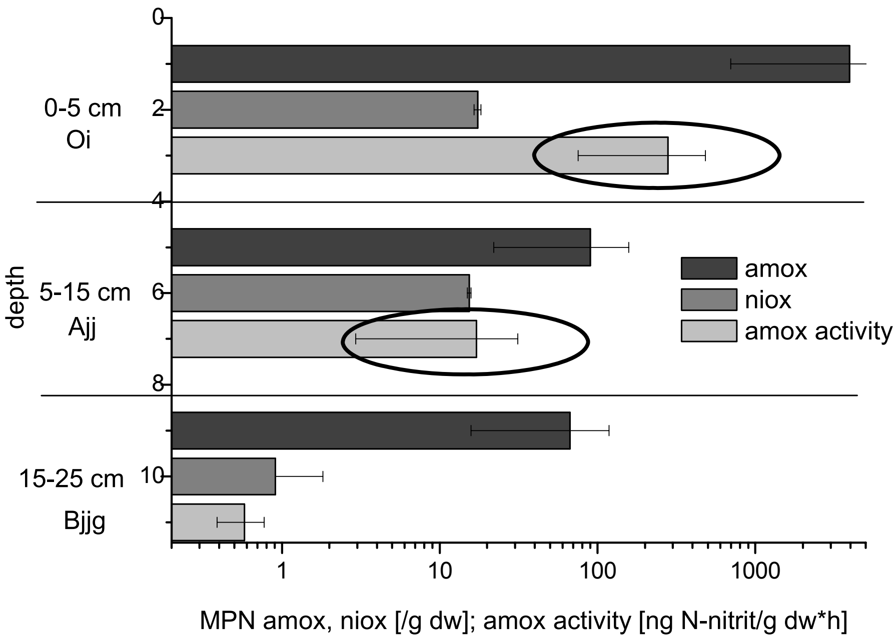


**Figure 3-5a:** Cell numbers of ammonia oxidizers (amox), nitrite oxidizers (niox) and ammonia oxidizing activities of soil samples of the polygon rim. Cell numbers were determined by MPN-technique after incubation for 9 weeks at 6°C. Activities were measured at 17°C and 0.75 mM ammonium.

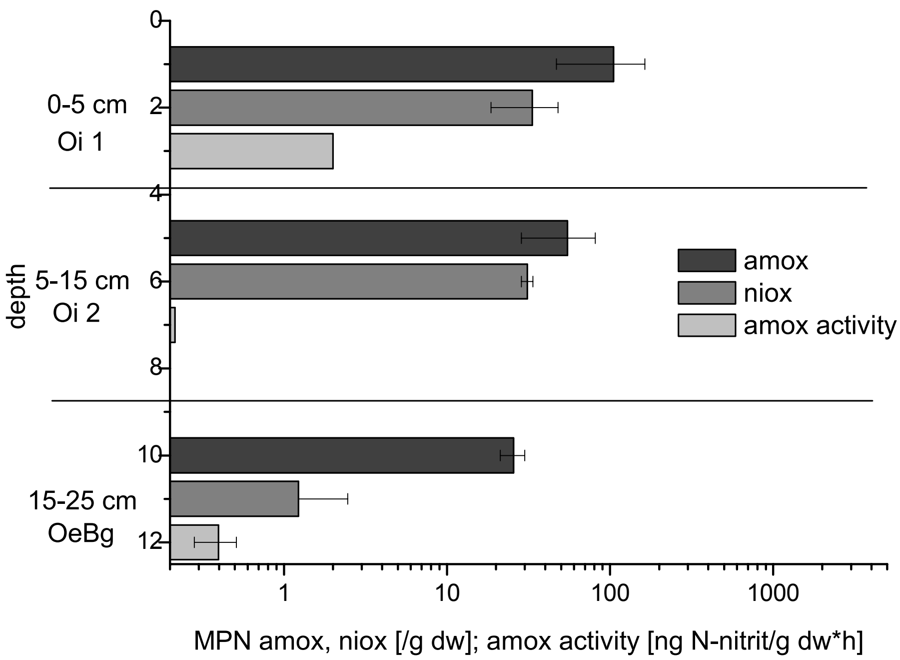


**Figure 3-5b:** Cell numbers of ammonia oxidizers (amox), nitrite oxidizers (niox) and ammonia oxidizing activities of soil samples of the polygon center. Cell numbers were determined by MPN-technique after incubation for 9 weeks at 6°C. Activities were measured at 17°C and 0.75 mM ammonium.

## 3.4 Closed chamber measurements of carbon exchange between Arctic tundra and the atmosphere

*Torsten Sachs and Dirk Wagner*

In addition of the long-term studies on methane emission carried out since 1998 (e.g. Wagner and Bolshiyanov, 2006), in 2005, an additional measurement field for closed chamber flux measurements was installed in close proximity to the eddy covariance tower. Altogether, 18 chambers were set up in four polygons and one polygon wall site (Figure 3-6). The four polygons are in different stages of development and feature different vegetation, with one polygon being a high-center polygon.

**Figure 3-6:** Air photograph of the measurement field for closed chamber flux studies in close proximity to the eddy covariance tower (on the left side in the photo background)

The purpose of these additional chamber measurements within the eddy covariance footprint is:

- to determine the small scale variability of carbon dioxide and methane fluxes and its influence on the quality of eddy covariance data

- to improve process understanding of the underlying single processes that make up parameters measured by eddy covariance

- to help develop robust models and scaling algorithms for up-scaling flux data from plot to landscape scale and beyond

The chambers consist of a 50x50 cm PVC base inserted about 10 cm into the active layer. A water-filled channel on top of the base provides a gastight seal between the base and the actual chamber. Four ports on top of the PVC chambers are used to draw sample air as well as to circulate the air inside the chamber with an external pump. Chamber volume is 12.5 liters and 25 liters where higher vegetation does not allow for the use of small chambers. Dark PVC chambers are used for measurements of respiration and transparent chambers are used for measurements of net carbon dioxide flux and methane flux. Measurements were conducted from August 7 through August 31, 2005 using an Innova AirTech Instruments Multi-gas Monitor Type 1302. For carbon dioxide fluxes, samples were drawn from the chamber headspace every minute for 5 minutes, and for methane fluxes samples were drawn every minute for 8-10 minutes. Samples were analyzed by photo-acoustic infrared spectroscopy and flux rates will be calculated from the change of concentration during closure time. Preliminary viewing of the data indicates some variability of fluxes within the micro-sites and clear variability between the different polygons. The high-center polygon shows fluxes more similar to those of the polygon wall than to those of other polygons. The clear decrease of photosynthesis visible in the eddy covariance data series can also be seen in chamber measurements of net carbon dioxide. Methane data show the most significant difference between polygon centers and the polygon wall with concentrations at the polygon wall micro-site reaching the instrument’s detection limit and very high concentrations at polygon center micro-sites.

## 3.5 Micrometeorological measurements of energy, water, and carbon exchange between Arctic tundra and the atmosphere

*Torsten Sachs, Christian Wille, Günter Stoof and Dirk Wagner*

The micrometeorological measurements of the years 2002 – 2004 were continued during the 2005 campaign. They comprised the determination of the turbulent fluxes of energy, water vapor, carbon dioxide and methane from the ground into the atmosphere using the eddy covariance technique, as well as the measurement of supporting meteorological and soil-physical parameters. The measurements lasted from July 17 through September 1. The investigation site and the technical set-up of the eddy covariance system (ECS) and supporting measurements were identical to 2003. For a detailed description see Kutzbach et al. (2004a).

The meteorological conditions on Samoylov Island during the study period 2005 are given in Figure 3-7a-c. The air temperature and net radiation show the usual diurnal pattern and also illustrate the seasonal progression from summer to autumn. The turbulent fluxes of sensible and latent heat, carbon dioxide and methane are presented in Figure 3-7d-g. The data series show clear diurnal and seasonal trends, except for methane. The sensible heat flux reached maximum daytime values of up to +200 W $m^{-2}$ and nighttime minimum fluxes of down to -50 W $m^{-2}$ until the end of July. After this, the sensible heat flux decreased to reach maximum daytime values of about +110 W $m^{-2}$; negative nighttime fluxes remained in the range of fluxes in July. Similarly, the latent heat flux showed maximum values of up to +200 W $m^{-2}$ in the first week of the campaign and remained mostly above 100 W $m^{-2}$ until the end of July. In August latent heat fluxes were typically below 100 W $m^{-2}$. $CO_2$ flux showed a clear diurnal pattern during the entire measurement campaign. Up until August 12, daytime $CO_2$ uptake typically reached or exceeded 100 µg $s^{-1}$ $m^{-2}$, while nighttime $CO_2$ emissions never exceeded 50 µg $s^{-1}$ $m^{-2}$. After August 12, photosynthetic activity began decreasing, resulting in daytime fluxes of typically only around -50 µg $s^{-1}$ $m^{-2}$. Methane flux measurements could also be conduced successfully. Methane fluxes showed no diurnal or seasonal trends. A strong peak with a maximum flux of more than 1.9 µg $s^{-1}$ $m^{-2}$ was detected on July 31 and corresponds to a peak in methane fluxes measured by closed chambers. Typically, methane fluxes remained below 0.4 µg $s^{-1}$ $m^{-2}$ and only exceeded 0.9 µg $s^{-1}$ $m^{-2}$ on three occasions during the entire measurement period.

Further work will go into the analysis and interpretation of this data.

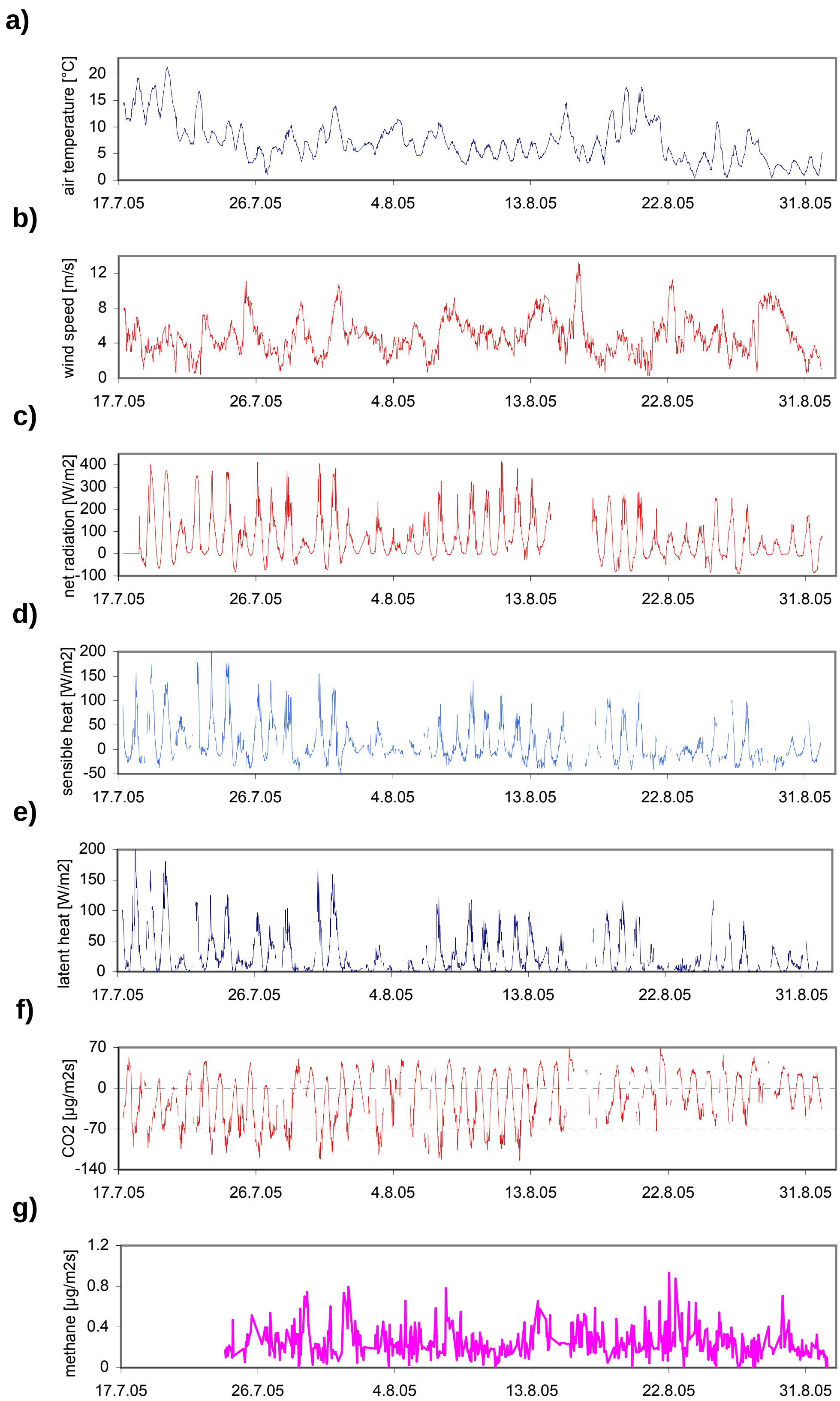


**Figure 3-7:** Data from the eddy covariance system on Samoylov Island during the study period July 17 through September 1, 2005. – a) air temperature at 2 m height, b) wind speed, c) net radiation, d) sensible heat flux, e) latent heat flux, f) carbon dioxide flux, g) methane flux. All values are half hour averages.

## 3.6 Energy and water budget of permafrost soils – long time meteorology and soil survey station on Samoylov Island

*Christian Wille und Julia Boike*

The permanent meteorology and soil survey station on Samoylov Island is situated about 200 meters northeast of the Lena Delta reserve station building on a Holocene river terrace which is characterized by polygonal tundra with raised, dry polygon rims and low, wet polygon centers. The station was set up during the Lena 2002 expedition and put into operation on 24.08.2002. For detailed information about the setup of the measurement station see Wille et al., (2003).

The data recorded by the measurement station and the sensors used are given in Table 3-4. Meteorological data (Pos. 1-5 in Table 3-4) was sampled every 20 seconds and hourly averages were stored. Soil temperature and heat flux was measured every 10 minutes and hourly averages were stored while snow height, electrical conductivity and volumetric water content were sampled and stored every hour.

During the Expedition Lena 2005 no changes were made to the measurement station. The meteorological sensors, the rain gauge and the snow height sensor were cleaned and checked for proper operation. The station had worked continuously since July 2004 and has thus collected continuous data since July 13, 2003. The raw data will be transferred to an SQL database which is hosted by the Institute of Environmental Physics at the University of Heidelberg and subsequently analyzed.

**Table 3-4:** Data and sensors of permanent measurement station

| Pos. | Data Measured | Sensor Type |
|---|---|---|
| 1 | Air Temperature and Air Relative Humidity<br>(0.5 and 2.0 m above ground) | Rotronic Meßgeräte GmbH<br>Meteorological Probe MP103A |
| 2 | Wind Speed & Wind Direction<br>(3.0 m above ground) | R M Young Company<br>Anemometer 05103 |
| 3 | Net Radiation<br>(1.35 m above ground) | Kipp & Zonen B.V.<br>Net Radiometer NR-Lite |
| 4 | Outgoing IR-Radiation<br>(1.28 m above ground) | Kipp & Zonen B.V.<br>Pyrgeometer CG1 |
| 5 | Precipitation (liquid, i.e. Rain)<br>(0.3 m above ground) | R M Young Company<br>Tipping Bucket Rain Gauge 52203 |
| 6 | Snow Height<br>(in centre of polygon) | Campbell Scientific Ltd.<br>Sonic Ranging Sensor SR 50 |
| 7 | Soil Temperature<br>(4 measuring profiles) | Campbell Scientific Ltd.<br>Thermistor Soil Temperature Probe 107 |
| 8 | Soil Bulk Electrical Conductivity<br>(3 measurement profiles) | Campbell Scientific Ltd.<br>TDR 100, Probe CS605 |
| 9 | Soil Volumetric Water Content<br>(3 measurement profiles) | Campbell Scientific Ltd.<br>TDR 100, Probe CS605 |
| 10 | Heat Flux out of / into Soil<br>(2 measurement points) | Hukseflux Thermal Sensors<br>Heat Flux Sensor HFP01 |

## 3.7 Isotopic Studies on the $^{13}$C-fractionation during $CH_4$-production in Polygonal and Thermokarst Lakes of the Lena Delta

*Eva-Maria Pfeiffer, Christian Knoblauch, Günter Stoof, Dirk Wagner and Hanno Meyer*

### 3.7.1 Introduction and methods

Besides the wet tundra soils small polygon ponds of ice wedge patterned ground and thermokarst lakes are important methane sources in permafrost affected landscapes (Semiletov et al. 1996, Makov & Bazhin 1999, Huttunen 2001, Spott et al. 2003, Spott 2003). During the last years many investigations focused on the microbial C-cycle of permafrost soils (e.g. Pfeiffer et al 2002, Wagner et al. 2003, Kutzbach et al. 2004b, Kutzbach 2005, Liebner and Wagner, 2006). But despite a close connection between C-soil- and C-lake-cycle, the strength of the lakes source is still not well investigated. During the expedition Lena 2005 different lakes of the polygonal tundra and one thermokarst lake on the Islands Samoylov and Kurungnahk have been investigated and sampled by a special sediment core equipment for lake sediments (see Fig. 3-8). Correlating soil and sediment next to the lakes are sampled. Additional ice samples of typical ice wedge and ice bodies of different near Samoylov Island were sampled for the determination of the $CH_4$ concentration and $^{13}$C signature. All samples have been degased in the field and the $CH_4$ concentrations have been determined with the field GC. The $^{13}$C-values of methane were determined at the Institute of Soil Science of the University of Hamburg using an isotopic-ratio mass spectrometer (Delta plus, Finnigan MAT) with a preconcentration unit (Precon), and a gas chromatograph (Agilent 6890) connected to the MS via a GC/C interface.

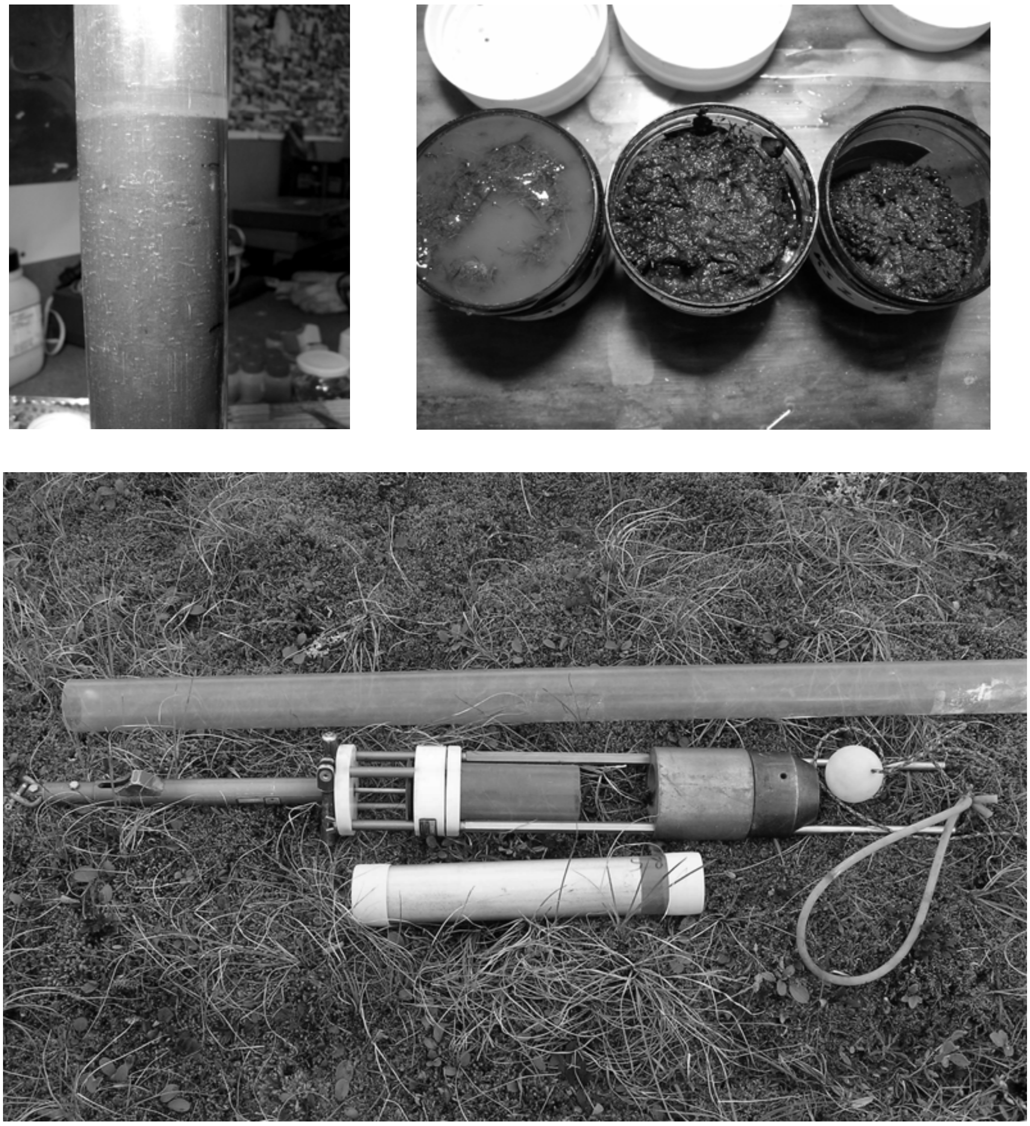

**Figure 3-8:** Sampling equipment and sediment samples (note oxic and anoxic zone in the core) of the thermokarst lake (Fish lake) on Samoylov Island, Lena Delta

### 3.7.2 Preliminary results and further plans

The methane concentrations of gas of the water column and sediment samples are shown in Fig. 3-9 and 3-10. The first results show a distinct isotopic fractionation of methane in the water column and of methane of sediments in different depth in the lake. The values range from -60 ‰ to max. -77 ‰ $^{13}$C. Methane concentrations were low in the sediment surface but increase in the deeper, anoxic sediment layers. Highest concentrations of 79 % methane were measured in gas bubbles of the reduced sediment (Fig 3-9a). The $^{13}$C-isotope signatures in the methane production zone showed very light values of -71 to

-77 ‰ (VPDB), as they are characteristic for archaeal methanogenesis. Methane at the surface showed lower concentrations and generally heavier $^{13}C$-values being indicative for an active methane oxidation in the surface sediments.

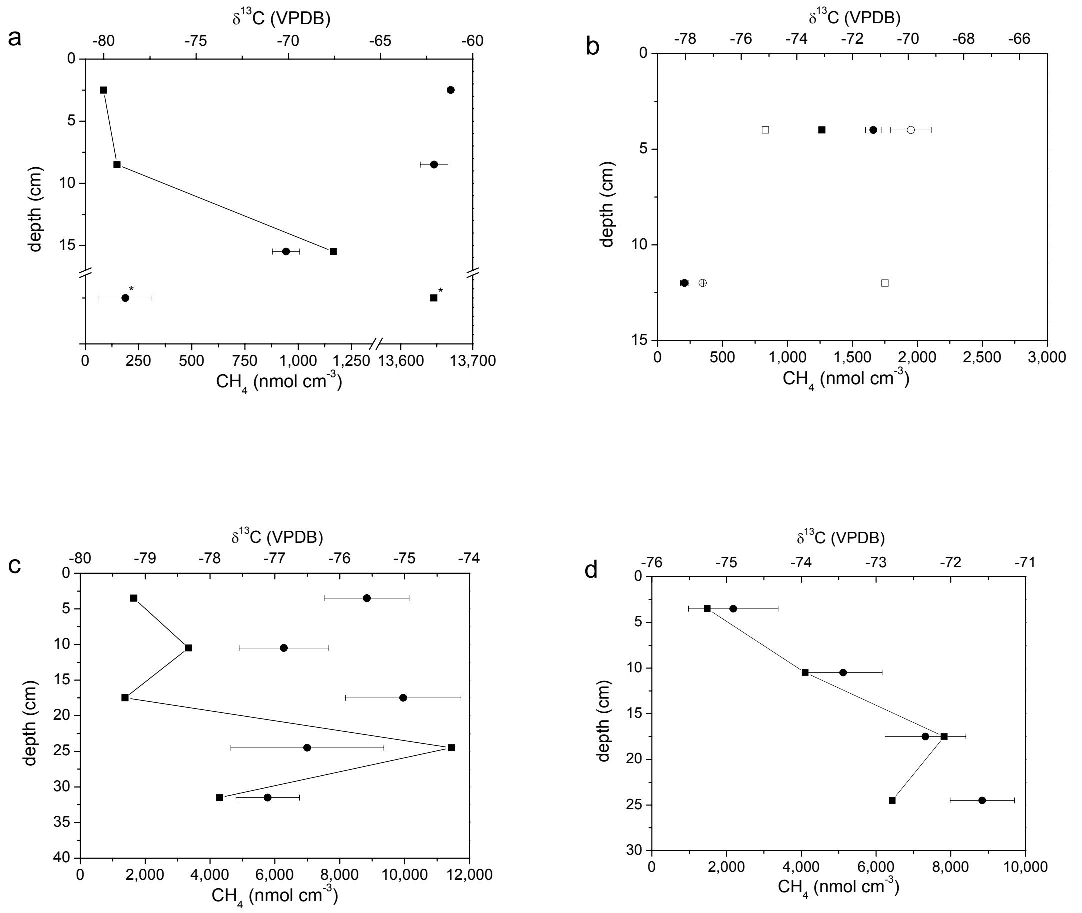


**Figure 3-9:** $CH_4$ concentrations (squares) and $^{13}C$-values of $CH_4$ (circles) of two polygonal lakes on Samoylov island (panel a and b Olly lake, sampling 1 m (panel a), 2 m (panel b closed symbols) and 5 m (panel b open symbols) from the shore line. Asterix in panel a marks values from gas bubbles from the anoxic sediment layer. Panel c and d KS-lake from Kurungnahk Island (c: KS 50 in 50 m and d: KS 100 in 100 m from the shore line) in the Lena Delta, August 2005.

The $^{13}C$ analysis have to be finished and interpreted in context of biogenic and geogenic methane formation. All so far determined values indicate the biogenic methane formation of $CH_4$ in the different lake compartments. Further investigations are necessary.

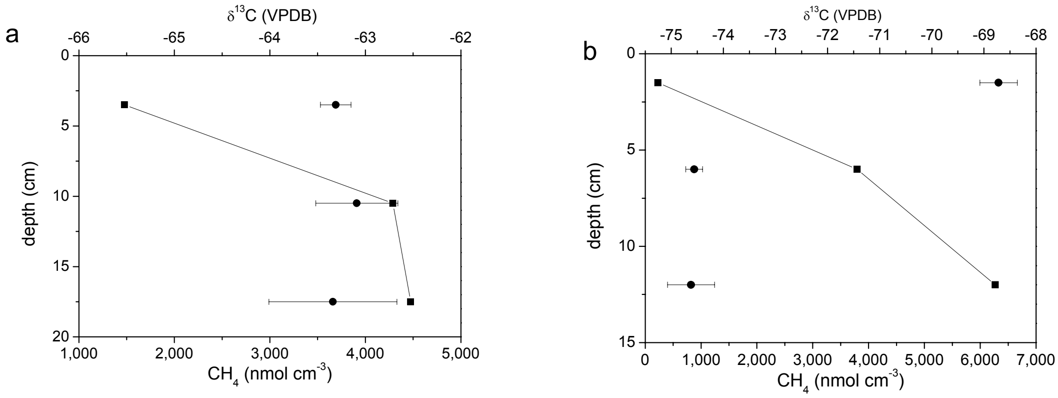


**Figure 3-10:** $CH_4$ concentrations (squares) and $^{13}C$-values of $CH_4$ (circles) in the water column (panel a) and sediment (panel b) of a thermokarst lake (Fish lake) on Samoylov Island, August 2005

## 3.8 Hydrobiological investigations in the Lena Delta

*Ekatarina N. Abramova, Günter Stoof and Waldemar Schneider*

### 3.8.1 Objectives

During last two decades of investigations we have got the detailed data about species composition and distribution of pelagic fauna in the different lakes of the Lena Delta. A total of 128 taxa of zooplankton were identified. The highest species diversity was found in the terrace lakes influenced by river waters in the period of spring runoff. Riverine waters bring nutrients, organic matter, phytoplankton, and zooplankton species into these lakes. The big thermokarst lakes of the second and third terrace are oligotrophic and isolated from river waters influence. Zooplankton of these lakes is poor qualitatively as well as quantitatively. Numerous polygonal ponds are the most productive ecosystems to compare with other types of the the lakes in the Lena Delta. The species composition is very similar in polygonal ponds situated in different parts of the delta. The homogeny in distribution of the pelagic fauna is seemingly related to wind-induced dispersion of inactive stages of the pelagic organisms after drying of polygonal ponds.

The seasonal dynamics of zooplankton species composition, abundance, biomass, and production has good pronounced in the different types of lakes conformities connected with environmental conditions and the live cycle of the common zooplankton species and depends on a certain year.

During the expedition "Lena-Delta-2005" the monitoring investigations of zooplankton on the Samoylov and Buor-Khaya Islands were continued.

### 3.8.2 Research tasks

To collect new data about biodiversity, ecology, population structure, and seasonal dynamics and production of zooplankton in the lakes on the Samoylov and Buor-Khaya Islands

To analyze the interannual variations in the zooplankton community inhabited of the different lakes ;

To estimate the influence of riverine water upon pelagic fauna formation in the different types of the lakes on the Samoylov Island

### 3.8.3 Material and methods

Sixty quantitative and twenty qualitative zooplankton samples were collected during the period of investigation (July – August 2005) on Samoylov Island: 17 samples – from flood-plain lakes, 10 – from deep polygon without plants, 10 – from shallow polygon with plants, 10 – from the crack between polygons, 23 -

from big thermokarst lakes situated in the different parts of the Island, 10 - from Olenekskya channel (Figure 1). Eight quantitative samples of zooplankton were collected from alases and polygons on Buor-Khaya Island.


**Figure 3-11:** Positions of zooplankton sampling on Samoylov Island: 1 - flood-plain lakes, 2 - polygons and ice crack, 3 - big thermokarst lakes, 4 - Olenekskaya channel

As in the previous years, sampling of zooplankton was performed by filtering of 50-100 litres of water through a 100-μm-mesh size net with periodicity of every 5-6 days and fixation with 70% alcohol or 4% borax-buffered formalin. In the big thermokarst lakes the vertical catches (from bottom to surface) were made with plankton net (0.05 m2 mouth opening, 100 μm mesh size).

Either the whole sample or part of it was analyzed in a Bogorov chamber under a binocular microscope "MBS-10". Detailed taxonomic composition and size of plankton organisms (with an accuracy of one hundredth of micron) were carried out using Olympus SZX9 and Olympus BX60 microscopes with the adjusted camera and computer program “Analysis” in the Otto Schmidt Laboratory in St.-Petersburg. To identify individual weights of organisms, we used the formula: W=qlb, where W is body weight, l – body length (mm), q – weight at 1 mm body length, b – index.

Characteristics of four taxonomic categories (Rotatoria, Anostraca, Copepoda and Cladocera) were studied in detail. Almost all adult organisms were determined to species level. Juvenile copepods were separated into copepodite stages and identified to species/genus level. Nauplii of Cyclopoidae and Calanoidae species (Copepoda) were counted separately, but without species identification. The abundance [ind./m3] was calculated for species, different age stages, principal taxa and total organisms in each sample.

Both total biomass, abundance, and species composition were associated with the temperature fluctuations of the water in the different water pools. Water temperature was measured simultaneously with plankton sampling.

### 3.8.4 Preliminary results

New data on species composition, distribution, productivity, and life cycles of plankton species were obtained as well as ecological aspects of their habitat use. As usually, a relatively low species diversity was discovered in the polygons with 27 zooplankton species on the Samoylov Island. Like in the last years, in July-August 2005, the taxonomic composition and abundance were dominated by the Heterocope borealis, several species of Diaptomidae family (Copepoda) and Daphnia pulex (Cladocera). The contribution of these species reach >80% of the total abundance and > 50% of the total biomass in the polygons lakes. A similar species composition and abundance of pelagic organisms was recorded in the polygons lakes on Buor-Khaya Island.

The highest species diversity and abundance were found in flood-plain lakes on Samoylov Island. Of all specimens collected from these lakes, about 90% belonged to Rotatoria and Copepoda species. Rotatoria (mainly *Keratella cochlearis, Asplanchna priodonta, Notholca acuminata, N. squamula, Polyarthra* spp. and *Euchlanis* spp.) and juvenile Cyclopoida and Harpacticoida constitute more than 80% of the total zooplankton abundance in July 2005. In August, the taxonomic composition and abundance were dominated by the same Rotatoria and Calanoida species belonged to Diaptomidae family and Eurytemora genus.

Different patterns of zooplankton composition in comparison with the privies years were observed in the flood-plain lakes on Samoylov Island in summer

2005 connected with the riverine water impact to these lakes during spring tide. Several new pelagic species for this region, such as *Eurycercus glacialis, Paracyclops fimbriatus, Macrocyclops albidus*, *Cyclops* sp. and others were found. Their share in the total zooplankton abundance in some flood-plain lakes on Samoylov Island was quite high, up to 30 % of the total number of organisms. According to our previous observations these species are common and abundant in the lakes on the Tit-Ary Island situated about 60 km to the south from Samoylov Island. It is possible, that we observe now the beginning of expansion of the boreal fauna representatives into the more northern regions is caused by the increasing influence of river run-off during last years. The trend in runoff observed in the Lena River basin increased by 10% from 1936 to 2001 due to the extended wet period during the second part of the last century (Berezovskaya et. al., 2005). An increased mean annual river discharge of 10-25% for the rivers that flow into the Arctic, with greater increases in winter and spring and a shift in the timing of peak flows to earlier in the spring is projected by models for the next 100 years (ACIA, 2004).

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# 4. Studies of periglacial landscape dynamics and surface characteristics studies in the western Lena Delta

## 4.1. Scientific background and objectives

*Lutz Schirrmeister*

Studies on the Late Quaternary history of the Lena Delta (Figure 4.1-1) were previously carried out in the frame of the Russian-German cooperation SYSTEM LAPTEV SEA between 1998 and 2002, and published in several papers (e.g. Schwamborn et al. 2002, Krbetschek et al. 2002, Schirrmeister et al. 2003). Based on these previous studies, new scientific questions arose that require the combination of already existing results with further field investigations.

Our group, based at a field camp in the north-western part of the Lena Delta (Figure 4.1-2), investigated permafrost sequences in sediment cores and exposures for palaeo-environmental construction and conducted studies on the characteristics of the thermokarst-affected landscape.

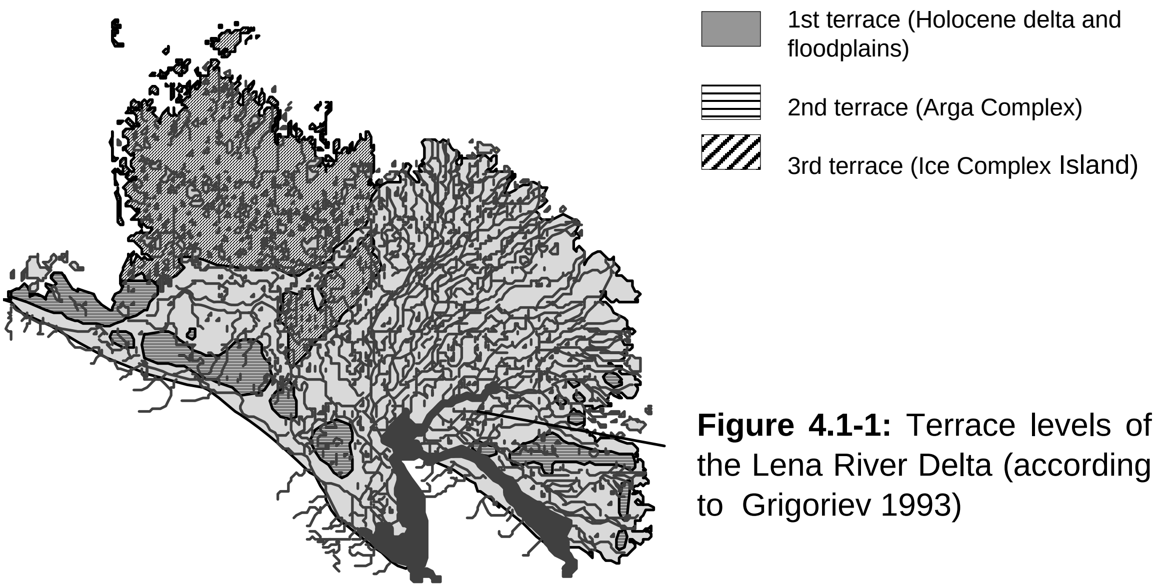



**Figure 4.1-1:** Terrace levels of the Lena River Delta (according to Grigoriev 1993)

One of the processes still unkown in the area is the genesis of the so-called “Arga-Complex”. The “Arga-Complex” is an extended sand complex, named after the largest island in the area – Arga-Muora-Sise. The deposits of this area, composing the 2$^{nd}$ terrace of the Lena Delta region were not accumulated under similar delta conditions like those of the 1$^{st}$ terrace of the Lena Delta formed in the Holocene (Figure 4.1-1). On the other hand the “Arga-Complex” is clearly distinguished from relicts of the Late Pleistocene Ice Complex formation of the 3$^{rd}$ terrace. Additionally, it is not clear, if the sand sequences forming the “Arga-Complex” could be facially and stratigraphically correlated with the sandy unit below the Ice Complex deposit along the Olenyekskaya Channel is not clear yet (Figure 4.2-1). Therefore the first objective was to descript the Quaternary history of “Arga Complex”.

The origin of the oriented lakes featured on the Arga-Complex is also under discussion since decades. Detailed geomorphologic (bathymetric and tachymetric) studies and surface observations would improve the understanding of the processes responsible for the formation of these lakes.

Finally, the study area features many different geomorphic units typical of arctic periglacial landscapes in Siberia. Their hydrological, sedimentological, morphological and botanical characterisation combined with the systematic measurement of spectral signatures will form the basis for the ground-truthing of multi spectral remote sensing data.

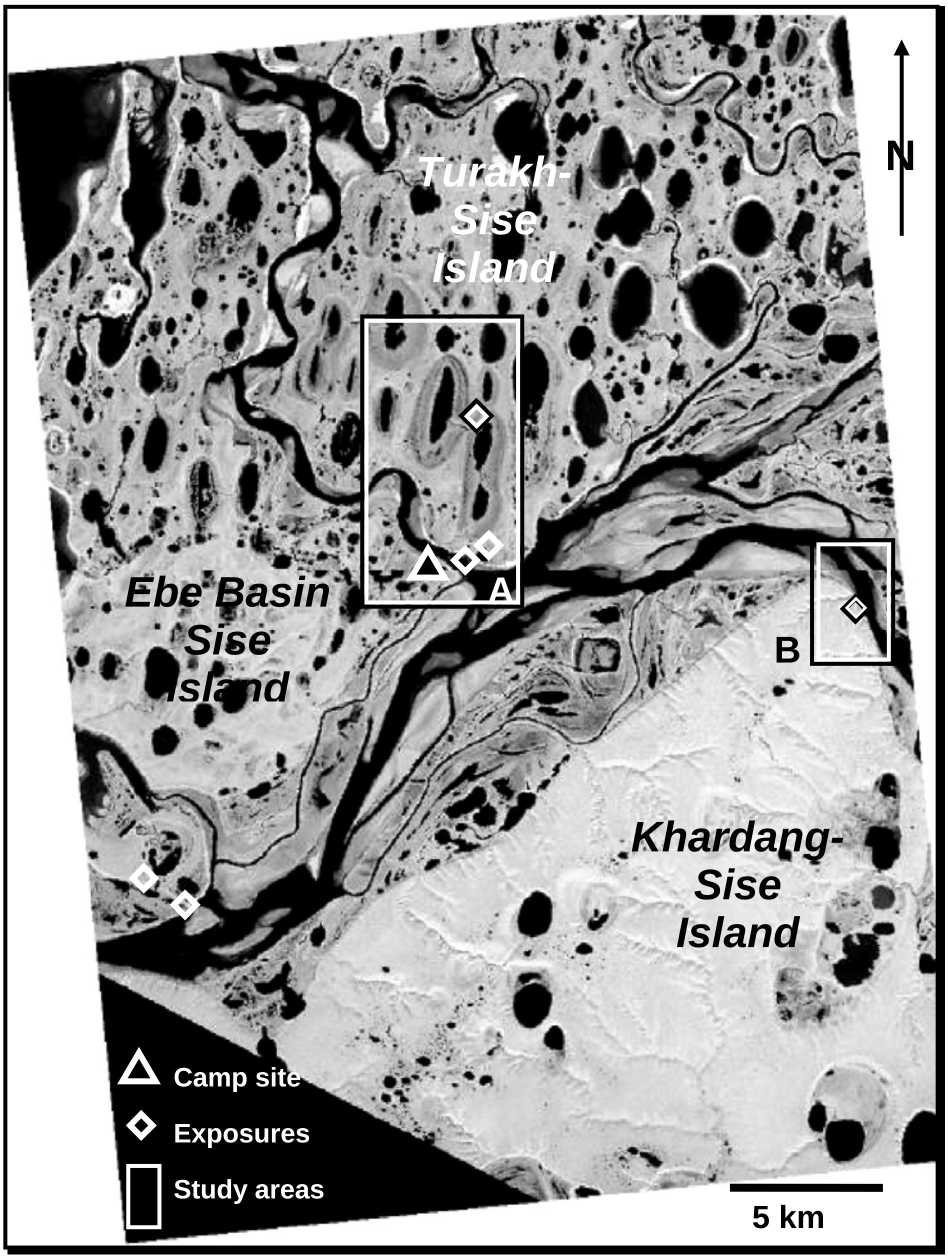



**Figure 4.1-2:** Study region in the western Lena Delta, (*Landsat T ETM+, July 24, 2001)*

## 4.2 Geological and geographical characteristics

*Mikhael Grigoriev, Viktor Kunitsky, Lutz Schirrmeister*

The study area, in the western part of the Lena Delta is bound to the east by the Tumatskaya Channel of the Lena Delta, to the south by the Chekanovsky Mountain Ridge, to the west by the Kuba Bay of the Laptev Sea, and to the north by the open Laptev Sea. Several islands in the western part of the Lena Delta, including Ebe-Basyn-Sise, Khardang-Sise, Dzhangylakh-Sise, and Kurungnakh-Sise are separated by the Bulukurskaya, Olenyekskaya, Arynskaya Channel, and other branches (distributaries) of the lower Lena River. The study area is characterised by the occurrence of the three typical terraces of the Lena River Delta (Figure 4.1-1).

- the 1$^{st}$ terrace (0-10 m a.s.l.): Holocene and modern delta floodplain, mostly along the main river channels
- the 2$^{nd}$ terrace (20-30 m a.s.l.): unclear origin; located in the north-western part of the delta
- the 3$^{rd}$ terrace (30-55m a.s.l.): remnant of a Late Pleistocene accumulation plain; located at the foot of the Chekanovsky Ridge.

The surface of the islands features complex Quaternary deposits. The composition and structure of these sediments have been described in a number of publications (Sachs and Strelkov, 1960; Gusev, 1961; Lungersgauzen, 1961; Grigoriev, 1966; Ivanov, 1972; Kolpakov, 1983; Galabala, 1987; Kunitsky, 1989). According to Galabala (1987), the sandy Muorinsky Suite (QII 1 – QIII 1) is totally covered by sands of the Turakhsky Suite (QIII 2) on Arga-Muora-Sise Island (Figure 4.2-1). The widely distributed sandy deposits, composing Arga-Muora-Sise Island, are correlated with the sandy unit exposed at the Olenyekskaya Channel below the Ice Complex unit (Figure 4.2-1).

New data on the composition and structure of Quaternary deposits from the mouth of the Lena River were obtained in the frame of the Russian-German cooperative scientific project “System Laptev Sea 2000” from 1998 to 2004 (Rachold and Grigoriev, 1999, 2000, 2001, 2003). Age determinations of a sandy sequence near the Lake Nikolay on Arga Island show that the sandy deposits at depths of about 1 to 4 m were formed between 14.5 and 10.9 ky BP (Krbetschek et al., 2002; Schwamborn et al., 2002). Whereas the sand unit below the Ice Complex along the Olenyekskaya Channel was accumulated between 60 and 100 ky before present (Schwamborn et al., 2002, Schirrmeister et al. 2004).

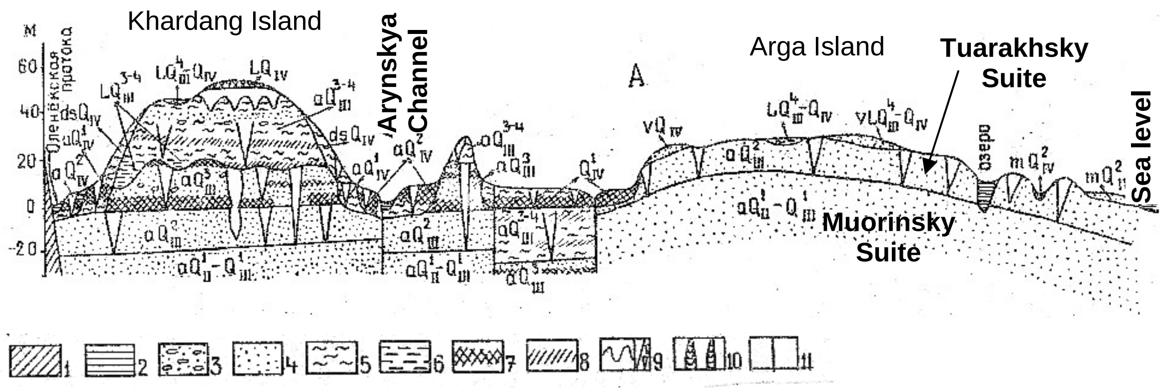



**Figure 4.2-1:** Schematic Profile of Quaternary deposits in the western part of the Lena Delta (Galabala 1987)

1 – Precenozoic basements; 2 –Paleogenic deposits; 3 – pebble horizon, conglomerate; 4 – Sands und pebble bearing sands; 5 – Loams and silts; 6 – Clays; 7 – peat; 8 – peaty silt and loam layers; 9 – Syngenetice ice wedges; 10 – Sediment-blocks within ice; 11 – Faults.

The genesis of the Arga Complex has thus yet to be fully explained. Opinions differ and call on marine, lagoonal, limnic-alluvial, alluvial-aeolian origin or glacifluvial, fluvio-nival accumulation to explain its occurrence. The most realistic hypothesis invokes the fluvial formation of old Lena River branches (Grigoriev 1993, 2000, Schwamborn 2000). The position of the Arga Complex is explained by tectonic uplift during the Late Quaternary (Are & Reimnitz 2000). Nevertheless the stratigraphic relations of “Arga sands” forming the 2$^{nd}$ terrace with the sandy sequences covered by Ice Complex deposits of the 3$^{rd}$ terrace have yet to be explained.

## 4.3. Studies of oriented lakes and thermokarst depressions

*Hugues Lantuit, Mikhael N. Grigoriev, Guido Grosse and Mathias Ulrich*

### 4.3.1 Background

Arga Island's morphology is ubiquitously characterized by the presence of elongated lakes up to 8 km wide and 6 km long. These lakes, like many others described in other parts of the Arctic, are ellipsoidal and oriented along a common direction, which grants them the denomination "oriented lakes". The axis of the Arga lakes is typically submeridional, (i.e. NNE-SSW) and their maximum water depth is in the range of 10-30 m (Grigoriev, 1993). The lakes feature deep large basins surrounded by shallow submerged rims, generally not deeper than 2m, and extending sometimes as much as 1km offshore.

Many hypotheses compete to explain the lakes' peculiar shape in Arctic landscapes. The supporters of the "wind hypothesis" argue that the wind is the prevailing agent in the formation of the elongated shape, which must be correlated to the wind dominant direction (Cote and Burn, 2002; Carson, 2001). Other authors (Pelltier, 2005) argue that the orientation of the lakes is mostly due to the general inclination of the relief over large distances. Grigoriev (1993) believes that the central lake basins on Arga Island are fluvial, lagoonal or deflation depressions that have been modified by periglacial processes, such as thermokarst. Are and Reimnitz (2000) think that a thawing of excess ice in the subsurface could have induces enough thaw settlement under the lake basins to lead to the present bathymetry. However, no discrete ice bodies have been detected yet in the Arga Island area to confirm this hypothesis. Schwamborn (2000), using a multidisciplinary and focused approach on Lake Nikolay, the largest lake on Arga Island, concluded, that "small ponds in abandoned fluvial pathways […] extended in depth and size due to thermokarst processes promoted in the ice-poor sandy subsurface".

The general lack of conclusive and extensive data on lake genesis in this region prompted the need for additional studies based on multiple approaches.

### 4.3.2 Study area

The latest field study concerned with lake genesis in the area focalised on the northern part of Arga Island, and in particular on Lake Nikolay, the largest lake on Arga Island (Schwamborn, 2000). Our study was therefore purposely located in the southern part of the "Arga Complex", in the vicinity of the Expedition Lena 2005 base camp, in order to compare both settings in our analyses and provide additional data to confirm or inform Schwamborn's hypothesis (2000) as well as to provide ground-truth data for satellite imagery (see section 4.3). We chose to focus on five depressions located on Turakh and on Ebe-Sise Islands. Three of these depressions are filled with lakes that are interconnected and drain into the Arinskaya Channel of the Lena Delta, The fourth depression is not connected with other lakes and does not drain into the Lena Delta channels. The fifth depression was located directly near the Arinskaya Channel (Figure 4.3-1). We named these depressions 1, 2, 3, 4, and 5 for practical purposes although these carry local names. The lakes located within the depressions inherited the numbers of the enclosing depressions.

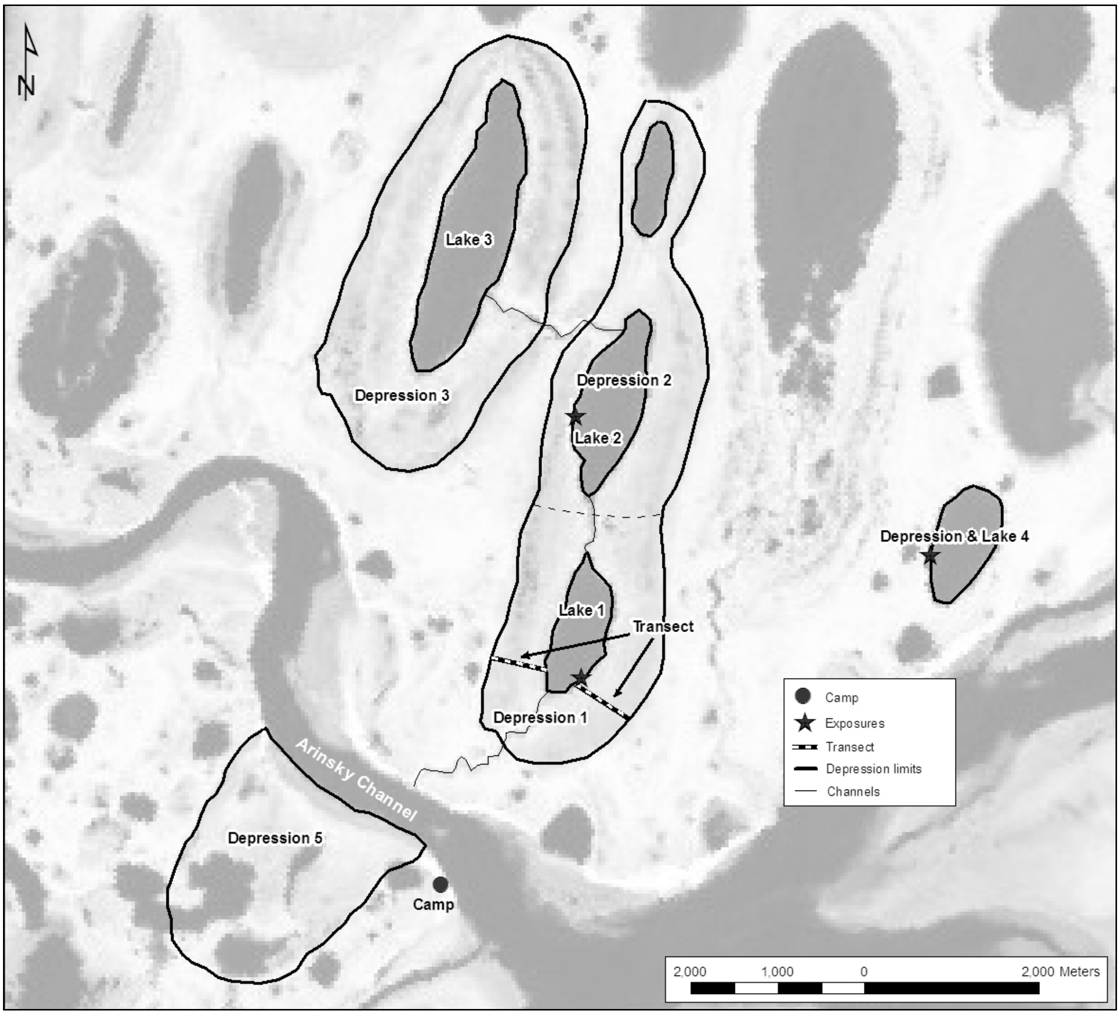



**Figure 4.3-1:** Study area and Lake nomenclature. The background image is a greyscale version of a Landsat color composite.

## 4.3.3 Topographical and geomorphological settings

### 4.3.3.1 Depressions 1, 2 and 3

Lakes 1 to 3 feature the same orientation that is a 20° inclination to the north. They are long and ellipsoidal and are interconnected. Lake 1 drains into lake 2 from its north most tip to the southern most tip of lake 2. Lake 2 drains into lake 3 from its north-western side shore to the western shore of lake 3. Lake 1 drains into the Arinskaya Channel at its southern most tip.

**Table 4.3-1:** Lakes geometrical features,

| | Length (m) | Width (m) | Maximum recorded depth (m) | Length/ Width ratio | Direction of ellipsoid's main axis (°) |
|---|---|---|---|---|---|
| Lake1 | 1180 | 470 | 3.0 | 2.5 | 25 |
| Lake 2 | 1580 | 540 | 9.5 | 2.9 | 25 |
| Lake 3 | 2500 | 620 | 9.5 | 4.0 | 30 |
| Lake 4 | 1010 | 500 | 3.3 | 2.0 | 30 |
| Depression1 | 2110 | 1320 | na | 1.6 | 25 |
| Depression 2 | 2250 | 1230 | na | 1.8 | 25 |
| Depression 3 | 3730 | 1610 | na | 2.3 | 30 |
| Depression 5 | 1790 | 1510 | na | 1.2 | 40 |

*na= non applicable*

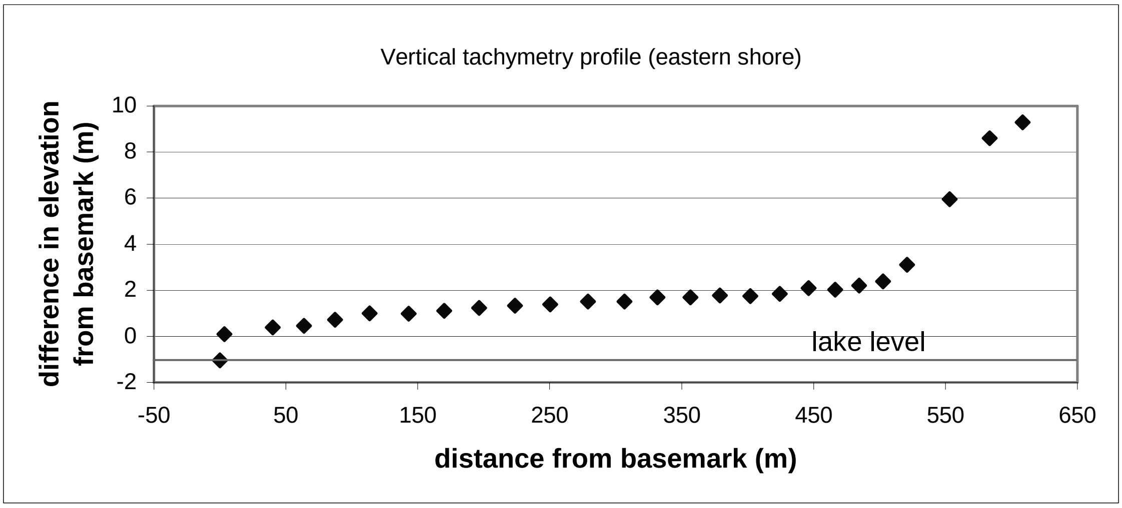
These three lakes are located into much larger (up to 1.6 km wide and 3.7 km long) interconnected ellipsoidal depressions. Concave stabilized cliffs of dry sand at the surface generally bind these depressions. The slope within the depressions between the foot of the cliff and the shore of the lakes is generally gentle and regular. The inside surface of the depressions is characterized by very moist to flooded ground surface.

Within the depressions, tundra polygon rims are distinguishable and are often double ridges are visible. These ridges are generally 30-40 cm higher than the surrounding ground level. These ridges create closed polygons ponds often flooded by 10 to 30 cm of water. The spacing between polygons ridges varies between 10 m in the driest areas and much greater spacing (> 20-30 m) in moister areas. Often a subtle change from double to single rims is distinguishable on these features. Single ridges are of similar height but are longer and sinuous and can extend over hundreds of meters in a direction subparallel to the lakeshore without intersecting any other ridge. They also create bound areas, which are flooded by 10 to 30 cm of water. These features are detectable on high-resolution satellite images and form sub-concentric circles around the lake between the shore and the foot of the cliff closing the depression.

Evidence of runoff is hardly visible within the depression. However, multiple water outputs from polygon edges at the shore showed us that water was draining into the lake from the surrounding depression. In addition, soil investigations at the cliffs surrounding the depressions brought us visible evidence that groundwater input from higher grounds was important (Figure 4.3-2).

**Figure 4.3-2:** An example of the significance of the permafrost table upon groundwater motion. This particular example taken at the top of the Arga sands formation at the location marked “camp” in figure 4.3-1

We conducted a topographical survey using a Trimble tachymeter in order to obtain a complete topographical transect of a depression. The survey was conducted in depression 1 in E-W direction, along the small axis of the lake ellipsoid (Figure 4.3-1). Survey marks were collected approximately every 20 m. In addition, the base mark of the survey was measured later from the shore of the Arinskaya Channel in order to obtain the elevation of the lake water level above the Arinskaya Channel. The resulting transect is shown in Figure 4.3-3.



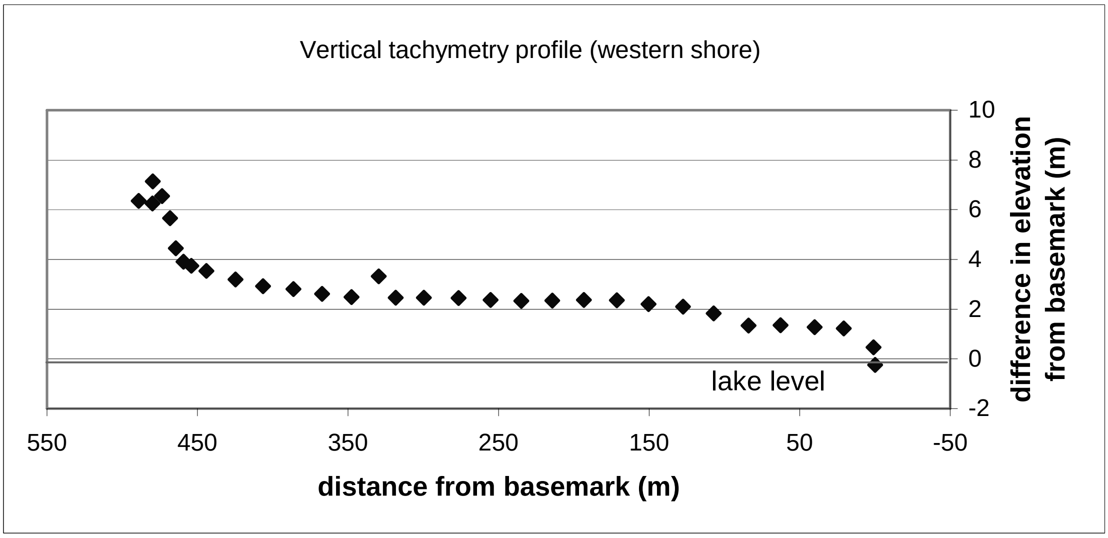




**Figure 4.3-3:** Vertical tachymetry profile of depression 1

Lakes 1, 2, and 3 are connected by narrow (< 10 m wide channels) where no evidence of the direction of the flow can be detected (Figure 4.3-4).

**Figure 4.3-4:** Upper part of channel connecting Lake 1 to the Arynskaya Channel

We observed two apparent opposed flow directions from one day to another under changing prevailing wind directions for the channels between lakes 1 and 2 and lakes 2 and 3. In addition, bathymetrical survey indicated the presence of underwater fans at both outlets for the three channels (chapter 4.3.4).

The channel between lake 2 and 3 flows in a narrow valley cut into the surrounding high grounds. Sandy cliffs up to 10 m high are exposed on the thalweg sides. The valley is approximately three to four times larger than the width of the channel at the time of the investigation. Since depressions 1 and 2 are merged into one single large depression, the channel between lakes 1 and 2 lays in a relatively low-lying setting, that is, similar to the rest of the depression surface, only surrounded by slightly elevated (< 2 m high) low-angle convexo-concave vegetated slopes.

The channel draining lake 1 into the Arynskaya Channel is constituted of two parts. The first one corresponds to the section of the flow located into the larger depression 1, and the second to the part located between the border of depression 1 and the Arynskaya Channel.

The first section of the flow is between 5 and 10 m wide. The channel is located into a wider topographically depressed channel, approximately 50 m wide, mostly vegetated, and characterized by the presence of polygonal grounds. The direction of the flow is also hard to detect in this section and strongly dependent on the direction of the wind.

The second section of the channel is less than 5 m wide, and flows for most of the distance as a narrow (< 2 m) channel. The flow is clearly directed towards the Arinskaya Channel and located in a narrower valley (< 20 m wide). The valley sides are steep and often non-vegetated or affected by slumping.

Driftwood is randomly distributed in depressions 1 and 2, from the bottom of the surrounding cliffs to the lake shore. We found driftwood logs as long as 5 m within these depressions. No driftwood was found in depression 3. Driftwood occurrence was greater in the channels connecting the lakes, including the channel connecting lakes 1 to 2, lakes 2 to 3, and the channel connecting lake 1 to the Arinskaya Channel. In the latter channel, huge logs, probably not older than fifty years and up to 20 m long were found in the depressed area surrounding the channel in its upper section (Figure 4.3-5).

**Figure 4.3-5:** Log found in the flanks of the channel connecting lake 1 and the Arinskaya Channel.

We observed the occurrence of several, mostly non-vegetated discrete fine sediment deposits, 2 to 4 m wide both in depressions 1 and 2 and in the channels connecting the depressions (Figure 4.3-6). The deposits were generally about 20 cm thick and lay over the surrounding vegetation. Because the vegetation buried by these deposits was often not at a dead stage, we concluded that these deposits were recent and probably deposited here by the spring floods of the Lena, and in particular by large ice fragments covered by sediment from the early flood.

**Figure 4.3-6:** Localized deposit of fine sediment overlying vegetation in the channel connecting lake 1 and the Arinskaya Channel

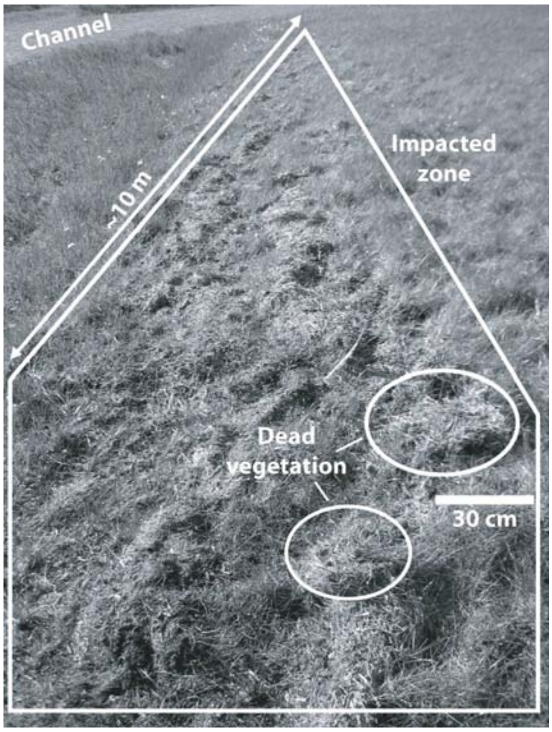



**Figure 4.3-7:** Deposit of dead vegetation on the flanks of the channel connecting lake 1 and the Arinskaya Channel

Within the depression surrounding the channels connecting lake 1 to lake 2 and lake 1 to the Arinskaya Channel, traces of destruction of the vegetation over tens of metres along a direction subparallel to the channels were observed. These traces were generally accompanied by the presence of recently degraded grass and small driftwood pieces along the path (Figure 4.3-7).

We think that these traces are also due to incoming ice during spring flood. A detailed investigation of satellite imagery further ascertained that depressions 1, 2, and 3 were flooded during spring floods (Figure 4.3-8).

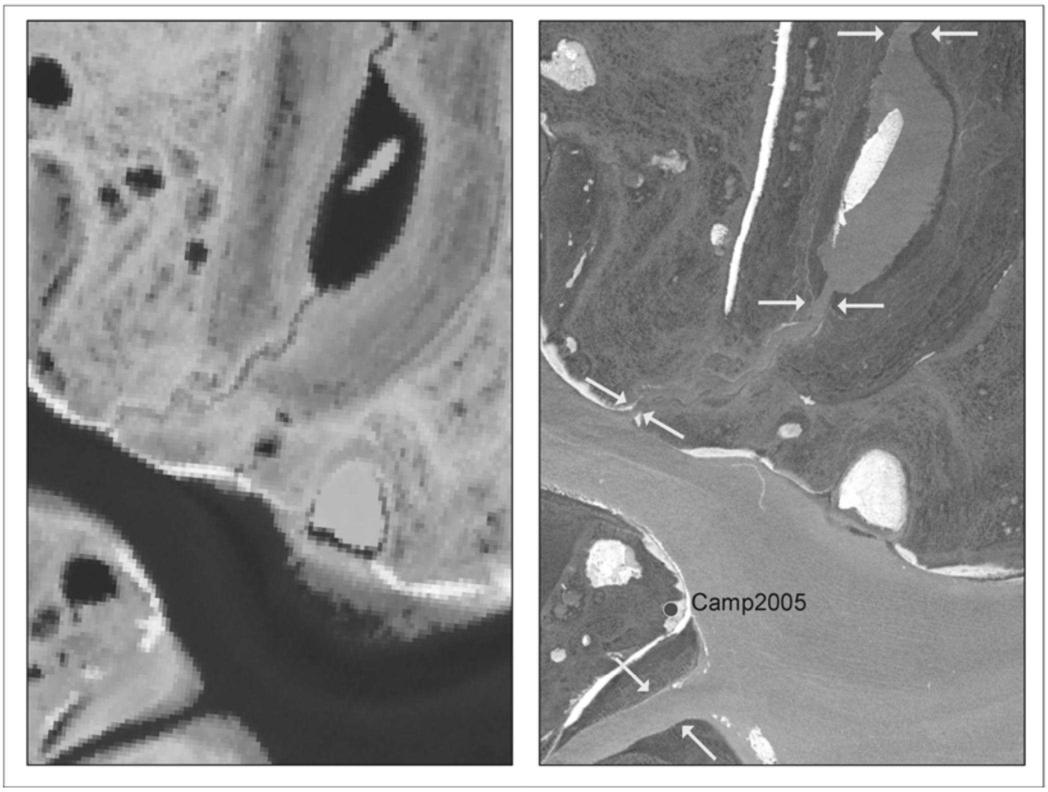



**Figure 4.3-8:** Water levels during summer (left) and during spring flood (right) for depression 1 (Left: 2005 late summer Chris Proba image; right: Archived 1970's mid-June Corona image)

**Figure 4.3-9:** Crescentic dunes on the top of the shore cliffs of lake 2 (29/08/05).

#### 4.3.3.2 Depression 4

Depression 4 was chosen because, contrary to depression 1, 2, and 3, it has no obvious connection to the Lena Delta channels. Also, depression 4 is entirely filled by a lake and considerably smaller than depressions 1, 2, and 3. Depression 4 is approximately 1010 m in length and 500 m in width. Its shape is rounder than the ones of the other depressions. The shores around lake 4 range between 0.5 to 3 m in height. On the western side of the lake, the shore material is exposed and consists mostly of a mixture of buried soils and sand overlying a thick sandy formation. No driftwood of discrete deposits such as the ones described in depressions 1 and 2 were found around lake 4.

#### 4.3.3.5 Depression 5

Depression 5 is located on the Ebe-Sise Island, on the south-west shore from the Arinskaya Channel. Its shape is generally ellipsoidal, although rounder than the other depressions and intersected on its north-east side by the Arinskaya Channel. Depression 5's bottom floor is also flatter than the ones of depressions 1, 2, and 3 and lays at a lower elevation. The north-east border of the depression is delimitated by a levee, approximately 0.5 m higher than the rest of the depression floor and 2 m higher than the flat sand surfaces in the riverbed. The levee is dryer than the rest of the depression, and covered by driftwood. Down this levee and next to the Arinskaya Channel, several isolated deposits of fine sediments, 20 to 30cm thick and lying over green buried vegetation were observed. We assume that these deposits are due to the melting of ice floes, similar to the ones described in depression 1.

The levee itself is steep and convex on the riverside and shows signs of vegetation destructions tracks, probably due to floating ice fragments.

Depression 5 is constituted of typical polygonal surfaces and small lakes. In contrast with depressions 1, 2, and 3, these lakes are not characterized by a common orientation and their shape are not ellipsoidal. In addition, they are not located in the centre of the depression, but rather randomly distributed. Observations from satellite imagery gave us indication that the depth of these lakes might be considerably lower than the ones observed for instance for lakes 2 and 3. We saw no indication of sub basins within the lake floor on satellite imagery. The depression is bound landwards by convexo-concave well-drained walls constituted mostly of sandy material. The overlying environment is one of dry sandy tundra and hummock-like non-sorted patterned ground.

Polygonal grounds into the depression are characterized by concentric to sub-concentric patterns. Immediately below the bounding walls, long polygon edges parallel to the walls can be observed expressing an overall radiant pattern for the entire depression. In centre parts of the depression, however, concentric to sub-concentric patterns can be observed around isolated ponds or lakes, which leads us to believe that these lakes are probably present since the depression was drained. The ground is generally very moist and the active layer is shallow (30-40 cm). Several discrete mound occurrences were observed in the depression. These mounds, between 4 and 7 in width, sub-circular in shape and risen 30 to 50 cm above the surrounding floor were observed where no obvious connection with a specific landscape feature could be asserted. The core of these mounds was sampled in situ and will be analysed in the laboratory. Collected samples were ice-rich. No specific bubble orientation or layering in the ice could be observed.

### 4.3.4 Bathymetrical surveys.

We conducted several bathymetrical survey on lake 1, 2, 3 and 4 using a manual echolot sounder operated from a rubber boat. The soundings were captured together with coordinates so that the results could be displayed in a GIS. The results of the bathymetry survey are shown in Figure 4.3-10 on a map. Figure 4.3-11 is a S-N transect representation from lake 3 bathymetry.

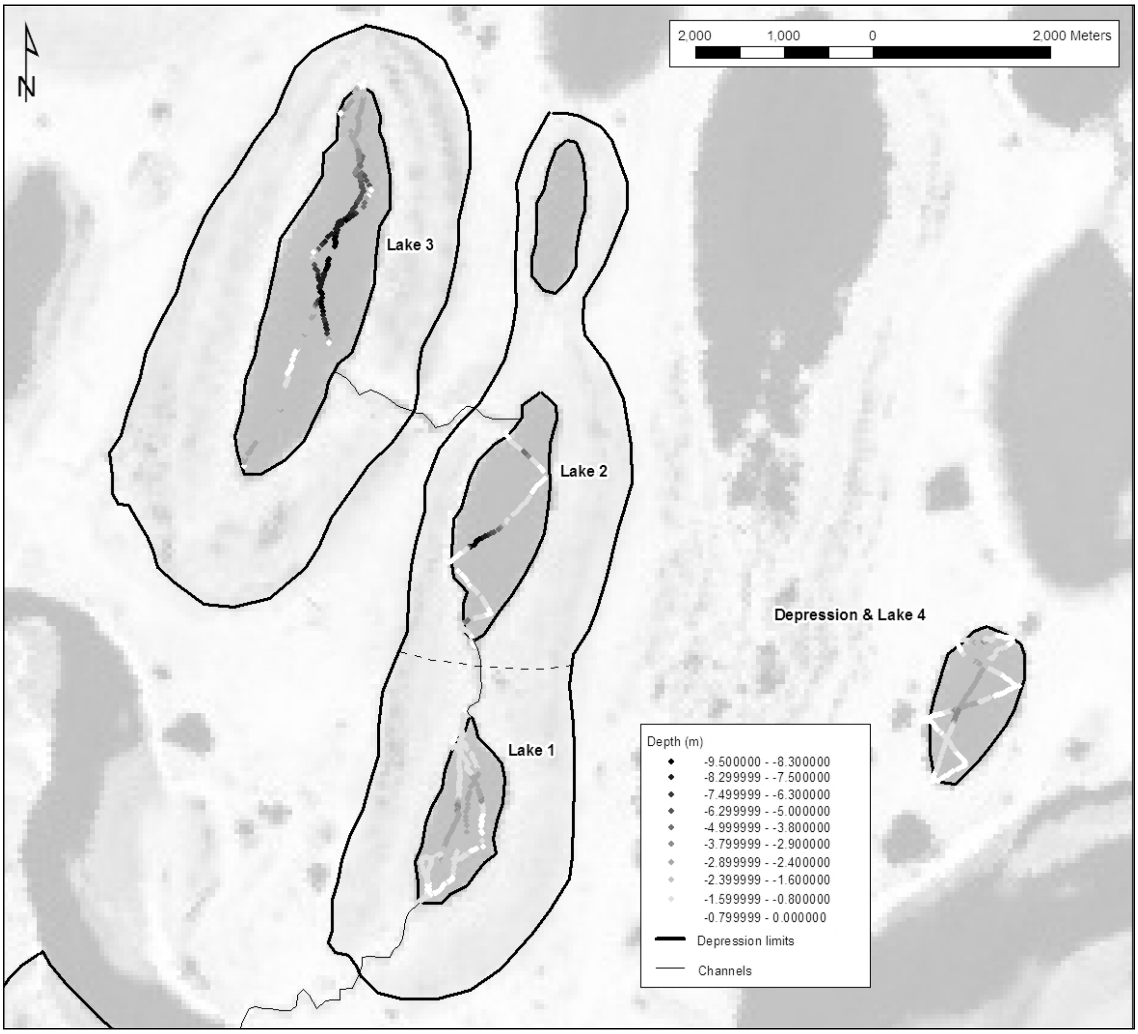



**Figure 4.3-10:** Map of bathymetric surveys


**Figure 4.3-11:** S-N bathymetric transect of lake 3

All four lakes featured three common elements:

1) a shallow platform (~1m deep) extending from the shore offshore,

2) a secondary and much more extensive platform (~2.5 m deep) extending from the limit of the first platform to the limit of the third element, and

3) an area characterised by deeper and non-flat grounds extending as much as 9.7 m deep in some lakes.

The latter element differed greatly from one lake to the other. Lake 1, for instance was found to extend only up to 3.3 m depth, while lake 3 extended as much as 9.7 m depth. Lake 4, unlike lake 2 and 3 was found to be shallower (up to 3.3 m). This scheme is consistent with the descriptions of Lake Nikolay's underwater topography by Schwamborn et al. (2000).

Lake 3 featured two deeper (deeper than 2 m) areas separated by much shallower ground in the central part of the lake. These shallower grounds were located immediately at the outlet of the channel connecting lake 3 to lake 2 and could be linked to the influx of sediment from spring floods, as hypothesised in section 4.3.6.

During the bathymetrical surveys, water samples were collected to obtain the isotopic signature of the lake water and compare it to the one of the Lena River (Tur-Lake-10-W1; Tur-Lake-10-W2)(Appendix 4-2).. The water samples were acquired in the middle of the lakes.

### 4.3.5 Field sampling

In order to get an insight into the genesis of the depressions, exposed sections within the depressions were investigated and sampled. Additionally, isolated samples were collected from driftwood and discrete sediment deposits. Sampling positions are listed and mapped on Figure 4.3-1 as star figures. Additional soil profiles were investigated in these depressions but are fully described in chapter 4.4. in this report. Three exposures were investigated in detail. The first one was situated at the eroding shore of lake1, the second at the eroding cliffs on the western shore of lake 2 and the third on the western shore of lake 4. An example of one of these sections in given in Figure 4.3-12


**Figure 4.3-12:** Soil exposure at lake 4 showing the strong contrast between the overlying succession of buried soils and the underlying monostructural and well-sorted sands

The isolated samples collected in the depressions consisted mainly of driftwood or sediment samples. Three driftwood samples at different levels of burial in the depression floor were collected in the southern part of depression 1.

The discrete fine sediment deposits observed in depression 1 and in the depressions surrounding the channels connecting the lakes 1 to 2, and 1 to Arynskaya Channel were also sampled.

Finally the “ice-cored mounds” observed in depression 2 and in depression 5 were sampled to establish ice content and to conduct sedimentological analyses.

## 4.4 Characteristics and spectral properties of periglacial landforms

*Mathias Ulrich, Guido Grosse*

### 4.4.1 Introduction

Remote sensing imagery is an excellent tool for the characterization of Arctic permafrost landscapes on large scales. Nevertheless, the successful interpretation of multispectral- and hyperspectral remote sensing data of spatially complex Arctic permafrost landscapes requires considerable field work for ground truth. This includes the acquisition of data on vegetation, soils, geomorphology, and also spectral surface properties.

A Landsat-7 based landcover classification for the entire Lena Delta was conducted by Schneider (2005). For this classification a Landsat-7 image mosaic of 3 scenes from 2000 and 2001 was used. The goal of this classification was the characterization and quantification of surface units and their usability for the up-scaling of locally measured methane emissions. The approach was based on available field data from several expeditions. Finally, 12 broad landcover classes could be differentiated. Several difficulties for the classification were encountered especially in delta regions with sparse field data. To overcome these difficulties and enhance the classification and results from it, more imagery from Landsat-7 and CHRIS Proba was acquired and additional field work was conducted during in 2005.

We collected extensive ground truth data in the central and western Lena Delta, NE Siberia, during the joint Russian-German expedition “Lena Delta 2005”.

The two main goals of our field work were:

- To provide the basic ground truth information necessary for the general characterization and classification of periglacial surfaces and geomorphological units in the Lena Delta by their spectral properties
- To provide ground truth data necessary for testing the application of hyperspectral data (field spectrometry and CHRIS Proba imagery) for the characterization of periglacial tundra landscapes

### 4.4.2 Methods

The delta is subdivided into three geomorphological terraces, which distinctly differ in their cryolithological, hydrological and geomorphological properties. These differences result in characteristic surface properties for the main units mainly influenced by hydrology, soils and vegetation composition. Our intent was to use the spectral variations between different land surface types to differentiate the major geomorphological units in the investigation area and conduct a file data based landcover classification.

Beyond general geomorphological mapping and description of surface properties, we used a portable field spectrometer to collect spectral data of a variety of typical periglacial surfaces in the central and western delta (Figure 4.4-1).

The field reflectance spectra were acquired in the spectral range 350 - 2500nm applying an ASD FieldSpec FR® Pro (Analytical Spectral Devices Inc.) (see Table 4.4-1 for instrument details). Usually the measurements were conducted on clear sky days around solar noon during August 2005. The data were acquired following procedures for calibration and referencing with a Spectralon® white panel (Labsphere, Inc.). For the acquisition of 1 spectrum a scanning time of 5 seconds was applied. Thus, according to the scanning time of the instrument (100ms) (Tab. 4.4-1), each acquired spectrum represents an averaging of 50 individual measurements. First, this procedure increases the signal-to-noise ratio of the instrument. Second, when the operator is moving forward during the 5 sec recording process, the resulting spectral signal is integrated over a larger field of view more representative for the typical heterogenic periglacial surfaces in the investigation area.

**Table 4.4-1:** Technical notes for the ASD FieldSpec®FR Pro

| | |
|---|---|
| Spectral range | 350 - 2500nm |
| 3 detectors | VNIR: photo-diode array (350-1000nm)<br>SWIR 1: scanning spectrometer (1000-1770 nm)<br>SWIR 2: scanning spectrometer (1770-2500 nm) |
| Wavelength accuracy | ±1nm |
| Ground resolution | - Variable (dependent on chosen fore optic and the distance between fore optic and ground)<br>- We used bare optics (24° field of view) and an altitude of 1m, resulting in a circle of about 0.2m radius |
| Spectral resolution | 3nm for 350-1000nm<br>10-12 nm for 1000-2500 nm |
| Data channels | 512 for 350-1000nm<br>1060 for 1000-2500 nm<br>interpolated data points: every 1nm (2151 total) |
| Field of view | Variable (dependent on chosen fore optic):<br>24° (bare optic), 1° or 8° (fore optic lenses) |
| Data acquisition | 1 scan every 100ms (0.1s)<br>(scans can be averaged to increase signal-to-noise ratio) |

**Figure 4.4-1:** Field spectrometry in the Lena-Delta. Calibration of the spectrometer using a Spectralon® white panel.

During the field work we carried out point and profile measurements with the spectrometer. Altogether, 19 sites were investigated:

Samoylov Island – 4 sites

Kurungnakh Island – 2 sites

Turakh-Sise Island – 2 sites

Ebe-Basyn-Sise Island – 11 sites (main investigation area in the western delta).

For each location, soil properties, active layer depths, geomorphological situation, and vegetation properties were recorded. More detailed information on the investigation sites are summarized in Appendix 4-1.

### 4.4.3 First results

During the field season 2005 more than 500 field spectra were acquired in the Lena Delta. A first assessment of the field spectra indicates a good spectral separability of the delta main terraces and thus significant differences in surface properties. Spectral differences in micromorphology (e.g. differentiation between polygon rim and centre) were also detected in the spectra. Main factors of the differences are vegetation composition, moisture content and vitality of vegetation cover. More advanced results of these investigations are summarized in the Diploma Thesis of Mathias Ulrich (Ulrich 2006).

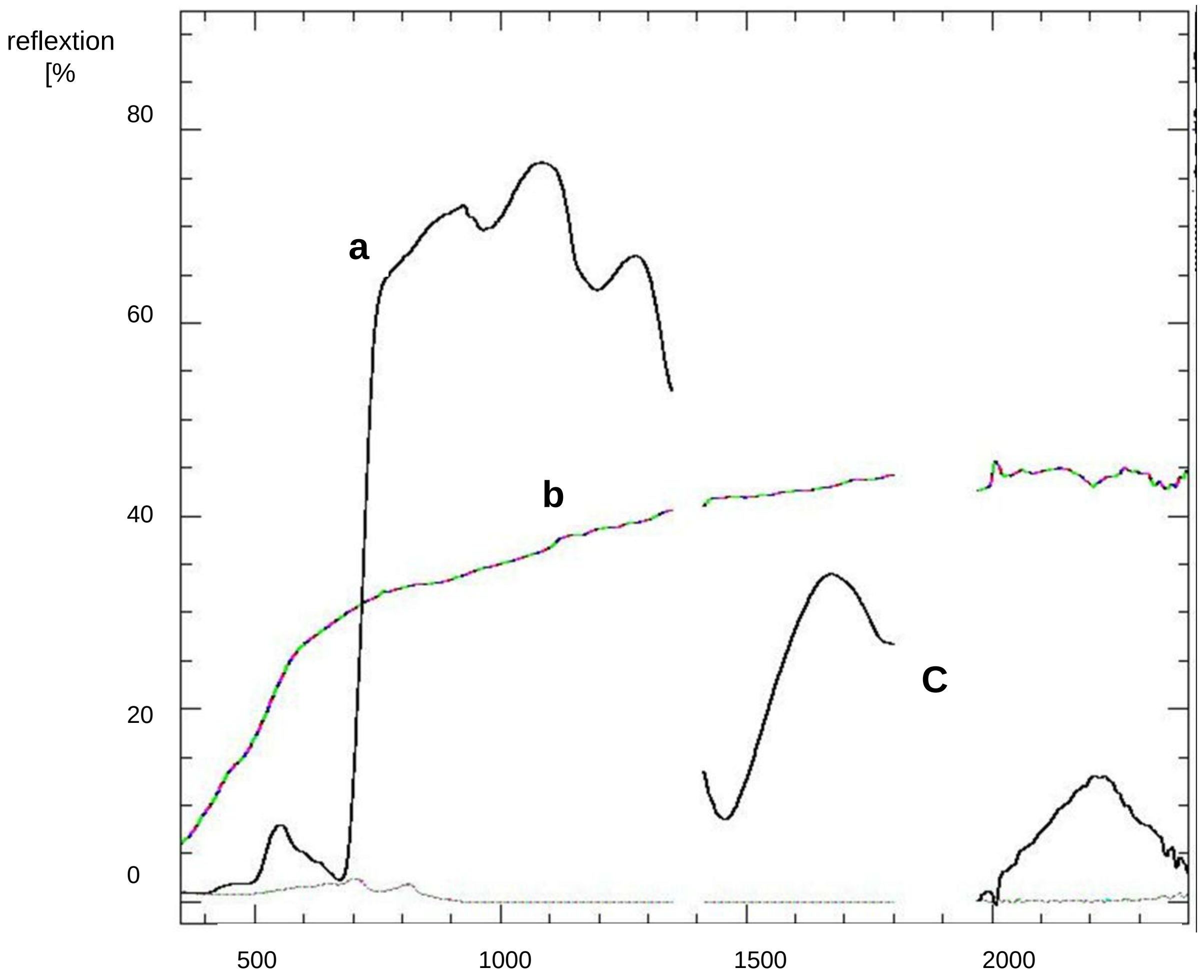



**Figure 4.4-2:** Exemplarily spectra of grass (a), sand (b), and water (c) of the study area

# 4.5. Studies of permafrost sequences for paleo-environmental reconstruction

## 4.5.1 The “Arga-Sands” on Turakh Island

*Lutz Schirrmeister, Guido Grosse, Mikhael Grigoriev, Waldemar Schneider*

In order to obtain a complete sediment profile of the sandy deposits, an exposure was studied on the left bank of the Arynskaya Channel. At this location, an outflow from an oriented lake located on Turakh Island (Fig. 4.1-1, chapter 4.3) flows into the Arynskaya Channel and exposes typical Arga-Complex sands. The exposure (Tur-1) was dug using shovels and cleaned with a scraper in order to reveal sediment and ice structures. The observed sedimentological and cryolithological features were described, drawn and photographed. 0.5 to 1.0 kg of frozen sediment was sampled using a hammer and a small axe for sedimentological, geocryological and paleo-ecological analyses. For age determinations using infrared stimulated luminescence method (IRSL), frozen samples were drilled with a hand-drilling machine (HILTI TE 5 A). A special drill head and opaque plastic cylinders as well as opaque plastic bags were used to protect the sample from sunlight exposure. Finally, samples of ground ice were collected for stable isotope and hydro-chemical analysis (see chapter 5) using ice screws or, for smaller ice bodies, only with a small axe. All samples are listed in appendix 4-2.

In order to obtain a thorough sediment profile of the “Arga-Sands”, a 11.43 m deep borehole (Tur-2) was drilled immediately In front of the exposure Tur-1 using a 6 cm diameter permafrost coring kit powered by a 2.9 kW engine (TKB-15, Fa. Lutz Kurth). The extracted cores were separated in 20 to 30 cm length bits. Most of them were retrieved in frozen state. Each core was then described, photographed and sampled every 10 cm. Approximately every meter, a core bit was sampled for ice content measurements. Gravimetric ice contents were then calculated using a relation to the dry weight of the samples.

Additionally, GPR surveys were carried out on top and bottom of the Tur-1 exposure (see chapter 4.6).

### 4.5.1.1 Exposure Tur-1 (72.97401° N; 123.79858° W)

The profile dug into the Arynskaya Channel bank exposed the entire 4.50 m high cliff (Figure 4.5.1-1). The lower (<2.00 m depth) part is composed of frozen sediment.

From 4.50 to 3.75 m depth, the profile shows cross-bedded fine- to medium grained sands, characterised by a massive cryostructure (samples Tur-1-S-1, S-15, S-16). Further up (3.75 – 3.25 m), fine-grained sand with small ice schlieres occur and feature diagonally-arranged ice structures. The uppermost frozen part of the profile (3.25 – 2.00 m) is characterised by the occurrence of brownish ice-rich sands with iron oxide impregnations, bands of humus enrichments and other indicators of soil processes (samples Tur-1-S-2 to S-6). The two latter horizons feature a specific type of ground ice: 10 to 20 cm wide ice-veins oriented both horizontally and vertically intersect to form a lattice-like structure. Although closer observations could hardly indicate which ground ice type it was, we acknowledged it as ice wedge ice, in reference to similar structures formerly investigated in Arga sands (Schwamborn et al. 2002c) (ice samples Tur-1-I-1 to I-15).

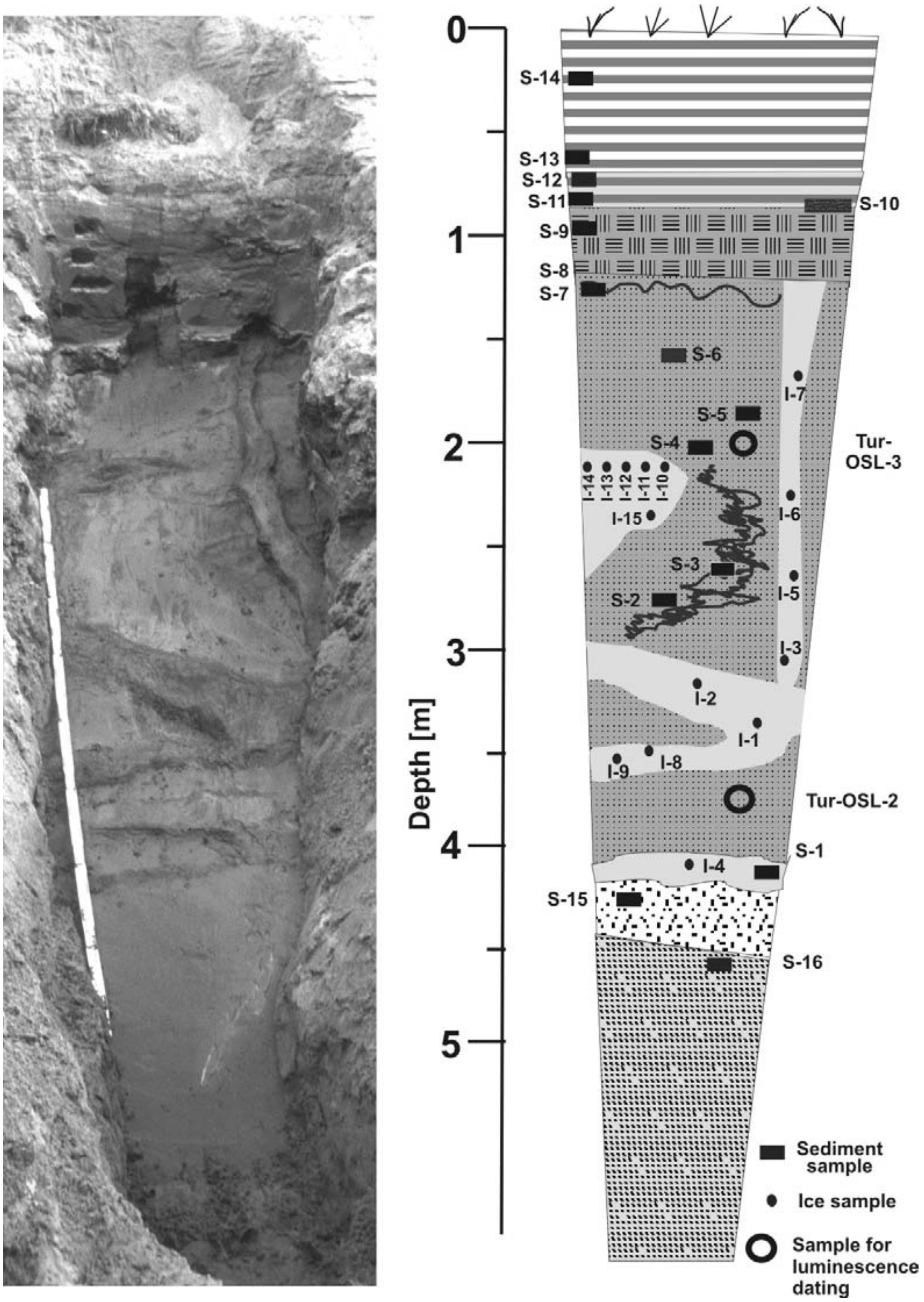



**Figure 4.5.1-1:** Outcrop scheme of the exposure Tur-1

The bottom part of the layer ranging between 3.25 and 2.00 m depth features a cryoturbated soil. His upper boundary corresponds with its upper permafrost table. An unfrozen peaty layer of 20 cm thickness in 1.2 – 1,0 m depth containing an wood stick covers the frozen sequence (samples Tur-1-S-7 to S-10). The next unfrozen horizon (1.0 – 0.8 m depth) is characterised by fine-layered alternation of thin (2-5 mm) brownish and grey lamina (samples Tur-1-S-11 to S 13). It looks like repeated aeolian covering of soil layers. The uppermost horizon of the exposure Tur-1 is composed of unfrozen well-bedded aeolian sand (dune) (sample Tur-1-S-14).

#### 4.5.1.2 Core Tur-2 (72.974° N; 123.7986° W)

*Lutz Schirrmeister, Guido Grosse, Mikhael Grigoriev, Waldemar Schneider*

The 11.43 m deep borehole was drilled between August 20 and August 29 (Figure 4.51-2). The daily drill progress was about 2 to 2.5 m. The 20 to 30 cm long frozen cores were cleaned with a knife and then described (Table 4.5.1-1), sampled and packed in plastic bags as 5-10 cm long segments. The first meter consisted of unfrozen beach sand (Figure 4.5.1-3). The next half meter featured similar structures to the ones exposed in the lower part of the Tur-1 exposure, in particular a thin, vertical ice vein. The middle part of the core sequence (1.53 to 5.78 m) consisted of greyish, bedded, fine-, middle-, and coarse sand characterised by a massive cryostructure. IAt a 5.83 m depth, a second ice vein occurred in the core. Further down (5.88 to 9.79 m), the sediment color changed to more spotty orange brownish patterns, caused by iron oxide impregnations. In addition, organic-rich interbeds and plant remains such as twig fragments were visible. A lighter mica-bearing horizon was cored between 9.79 to 10.34 m depth. The lowermost part of the core (10.34 to 11.43 m) was characterised by numerous small black inclusions of probably coal fragments.

**Figure 4.5.1-2:** The drilling machine TKB-15 in front of the exposure Tur-1

In general, the gravimetric ice content varies between 20 and 40 wt%. with only two peak of ice-rich layers (Figure .4.5.1-3). Temperature measurements were carried out three days after finishing to drill using the resistance measurements of calibrated thermistors (MMT-4) of the Permafrost Institute Yakutsk.

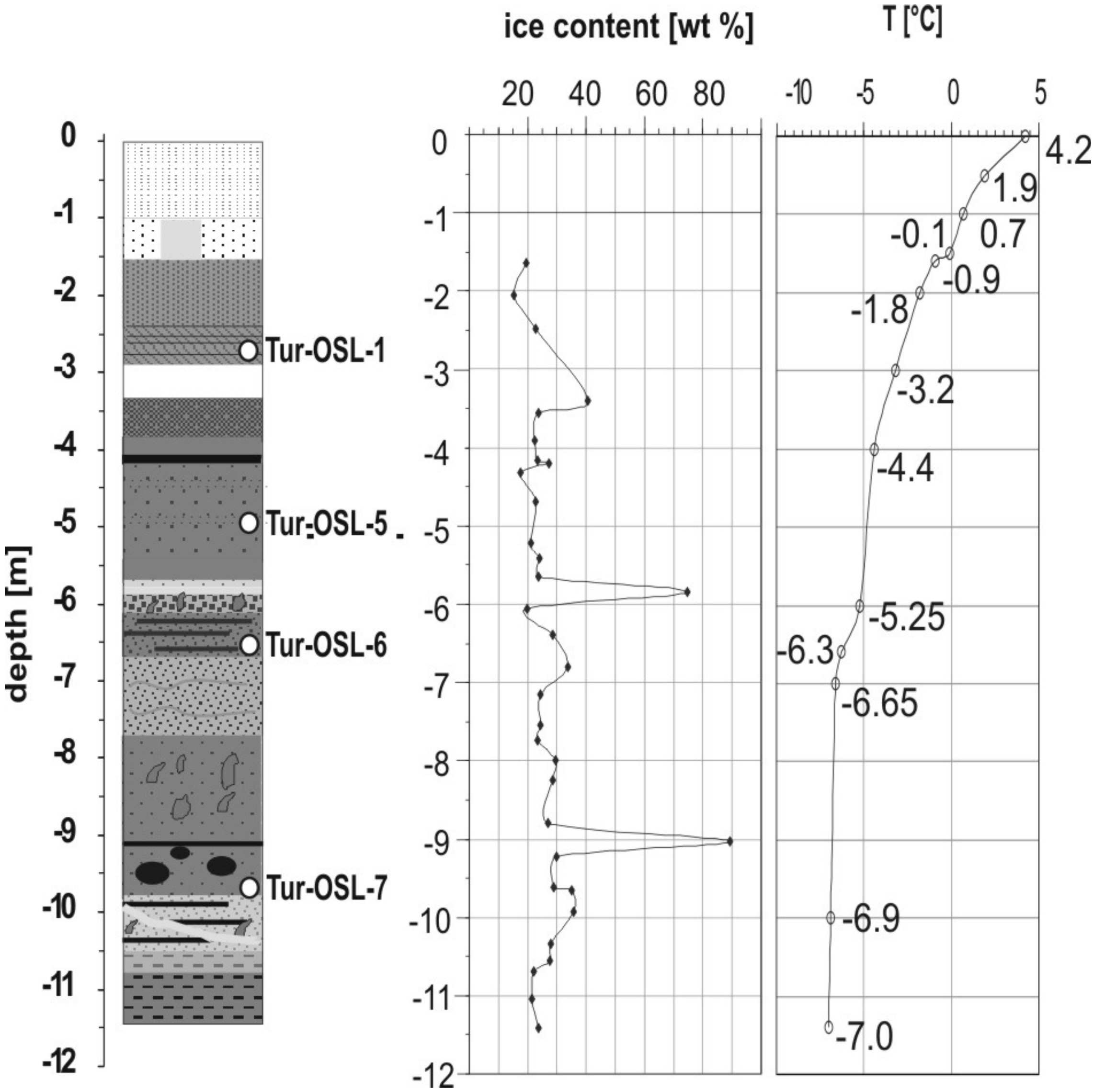



**Figure 4.5.1-3:** Schematic profile of the core Tur-2 with measurements recorded in the field, Temperature measurement was carried out in August 31, 2005

**Tabble 4.5.1-1:** Core description Tur-2

| **Depth [m]** | **Description** |
|---|---|
| 0.0 - 1.0 0 | Beach deposits, active layer, unfrozen sand |
| 1.00 – 1.10 | Frozen fine sand, similar to the one exposed in the lower part of exposure Tur-1 |
| 1.10 – 1.53 | Vertical ice vein, 2 cm wide, in frozen fine sand |
| 1.53 – 2.40 | Greyish brown sand, massive cryostructure |
| 2.40 – 2.85 | Cross-bedded sand, small silty interbeds, greyish-brown |
| 2.85 - 3.35 | *Core loss* |
| 3.35 - 3.85 | Fine sand to middle sand greyish-brown, Tur-OSL-1 (3.6-3.77 m) |
| 3.85 – 4.25 | Interbedded fine middle and coarse sand, 4.12-4.18 m: organic-rich layers |
| 4.25 – 5.60 | Fine and middle sand interbedding, Tur-OSL-5 (4.95 – 5.07 m) |
| 5.60 – 5.78 | Graded bedding, thin laminaes, fine sand, middle sand |
| 5.78 – 5.83 | Ice-rich sand |
| 5.83 – 5.88 | Ice vein, vertical gas bubbles |
| 5.88 – 6.10 | Greyish-brown middle to fine sand, Fe-oxide spots. |
| 6.10 – 6.58 | Interbedding, middle sand and organic-rich layers, Fe-oxide bands, Tur-OSL-6 (6.43-6.58) |
| 6.58 – 7.65 | Greyish-brown fine to middle sand, non-bedded, fine-distributed plant remains, Fe-oxide spots, massive cryostructure |
| 7.65 – 9.13 | Greyish, fine sand, middle sand, weakly bedded, small plant remains, spotty |
| 9.13 – 9.79 | Fine sand, middle sand layers, organic-rich inclusions, brown-spotty, Tur-OSL-7 (9.66-9.79) |
| 9.79 -10.34 | Light greyish-brown, medium sand, fine sand, mica-bearing, brown-spotted, single thin organic-rich layers, 2 mm ice band |
| 10.34 – 10.77 | Greyish fine sand, brownish medium sand, weakly bedded, without plant remains |
| 10.77 – 11.43 | Greyish fine sand, brownish medium sand, weakly bedded, black coal-like inclusions |

### 4.5.1.3 Exposure T021 (73.00°N, 123.830°E)

An additional exposure was dug into the terrace of the 2nd thermokarst lake on Turakh Island in order to continue the study of Arga-Complex deposits (see chapter 4.2). This profile exposes about 2 m of different sand layers (Figure 4.5.1.-4).

The permafrost boundary is located 1.25 m below the surface. The lowermost grey, frozen sands (samples T021-9 to –11, gravimetric ice content 15 to 20 wt%) are characterized by orange-brown coloured crack-like structures, which are lattice-like oriented. This lattice-like structure is similar to the one described in the exposures Tur-1 (chapter 4.5.1.1) and Ebe-4 (chapter 4.5.2.1) and typical of the "Arga-type" ice wedges. Above the permafrost boundary, a bedded sand with grey to orange colour alternations occurred (sample T021-8). This layer is covered by 25 cm thick sand with dark-brown iron-oxide schlieres (samplesT021-7 and –6). In 0.50 to 0.75 m depth a layer with horizontal, orange-brown bands was visible (samples T021-5 and –4). Higher between 0.25 to 0.5 m depth the well-bedded sand contains more organic and was spotty orange to grey coloured (sample T021-3). The uppermost part of the profile consists of grey and light-yellowish sand with roots (samples T021-2 to –0). Finally, a about 0.5 m thick layer of dune sand was accumulated at the surface.

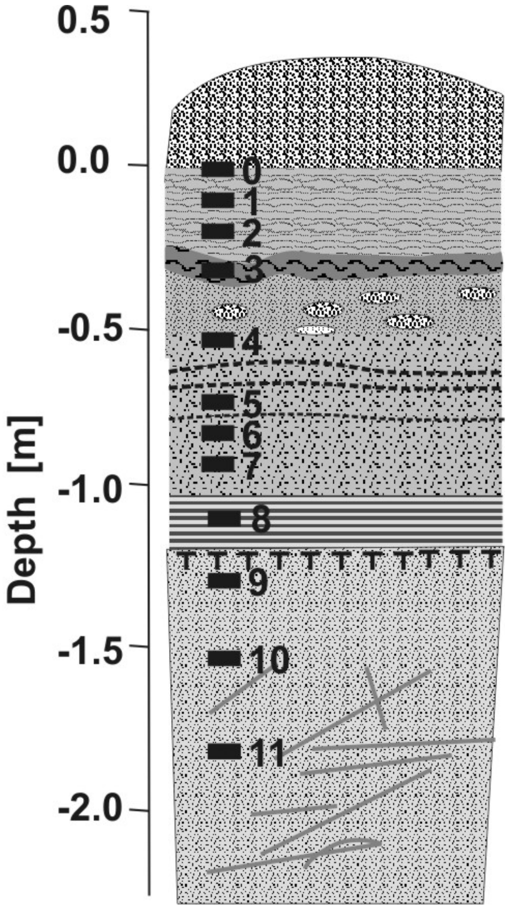



**Figure 4.5.1-4:** The sand profile of the T021 exposure

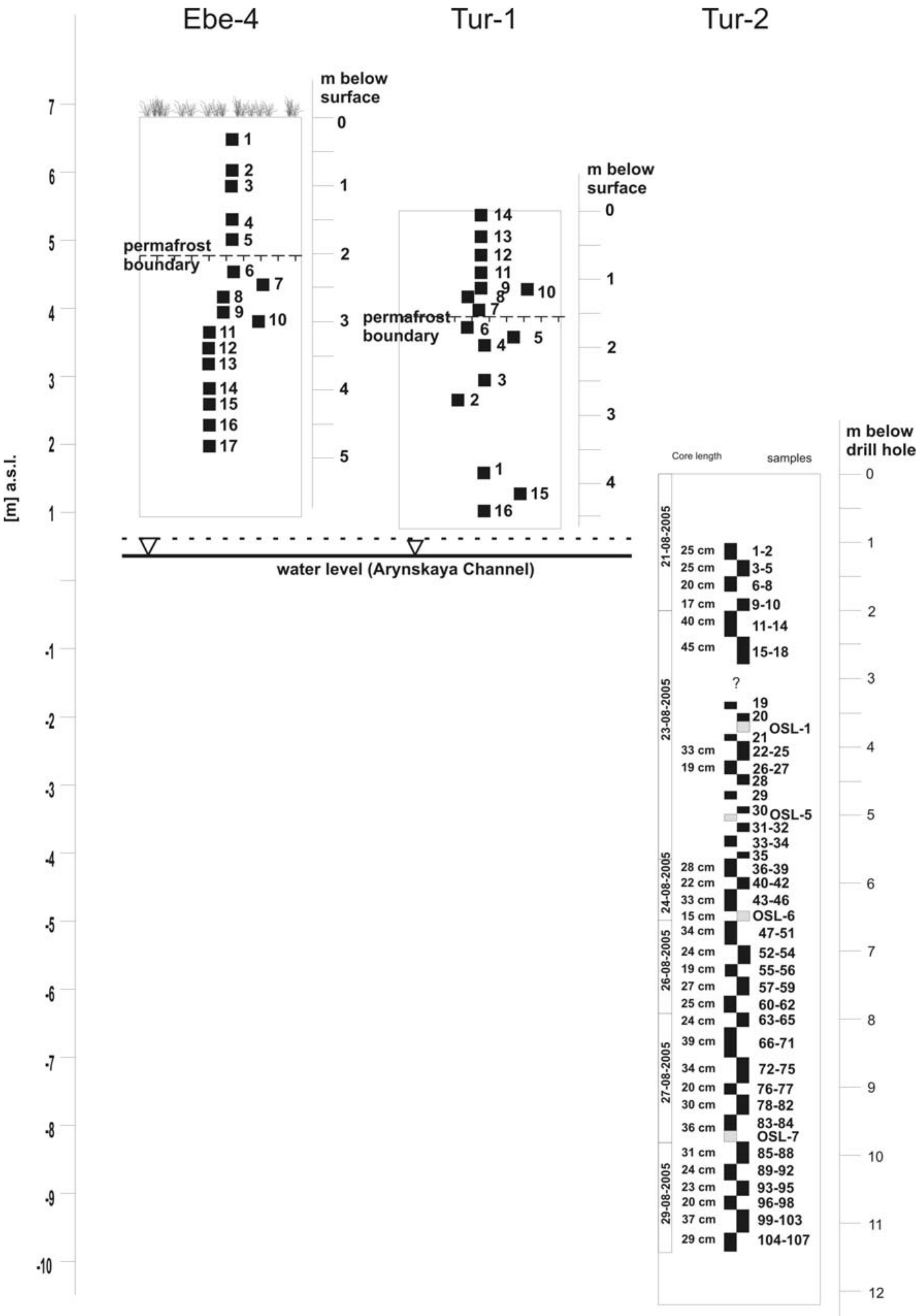



**Figure 4.5.1-5:** Correlation of the profiles Tur-1, Tur-2 and Ebe-4 based on tachymeter surveys

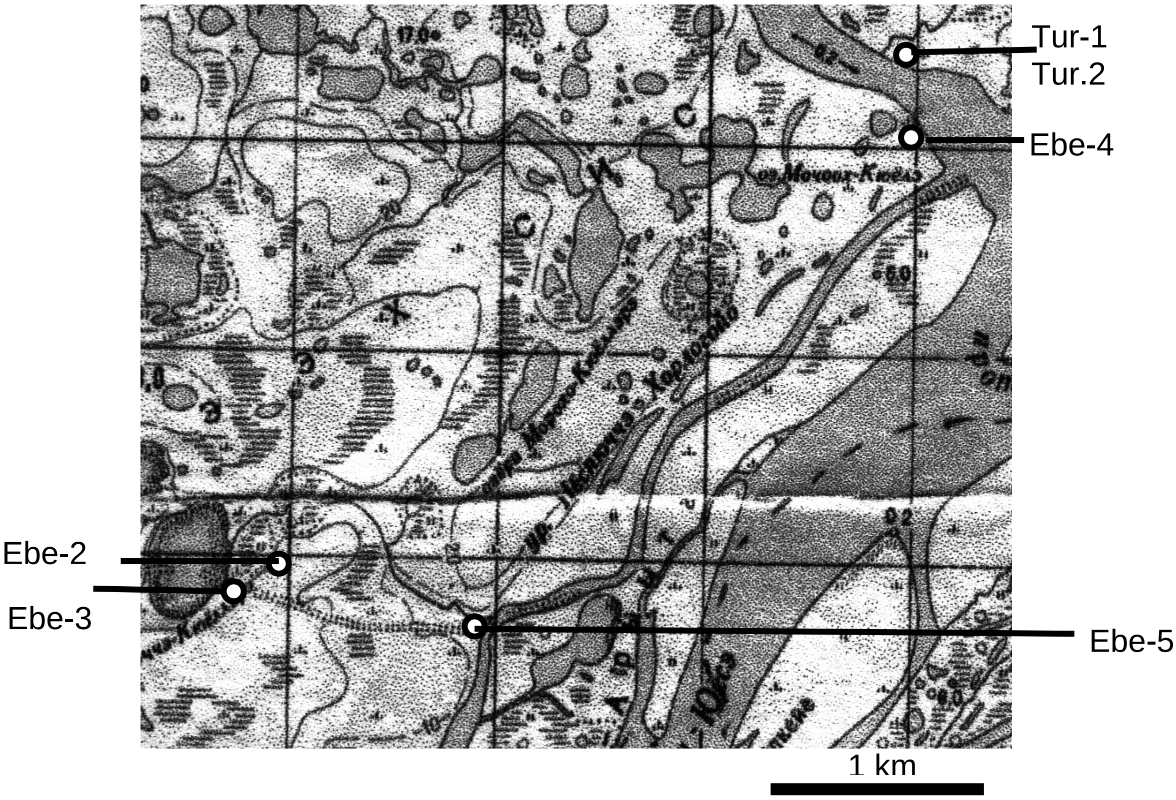



**Figure 4.5.1-6:** Exposure locations at Turakh Island and Ebe –Sise Island

### 4.5.2 Sand sequences of Ebe Basyn Sise Island

*Lutz Schirrmeister, Mikhael Grigoriev, Tatyana Kuznetsova*

4.5.2.1 Exposure Ebe-4 (72.965°N, 123.807°E)

A second large outcrop was dug just next to the camp site into the left bank of the Arynskaya Channel. The outcrop was dug in a 7 m high cliff, made of sands from the "Arga Complex" (Figure 4.5.2-1). The profile itself was about 5 m long. Only the lowest 3 m were frozen.

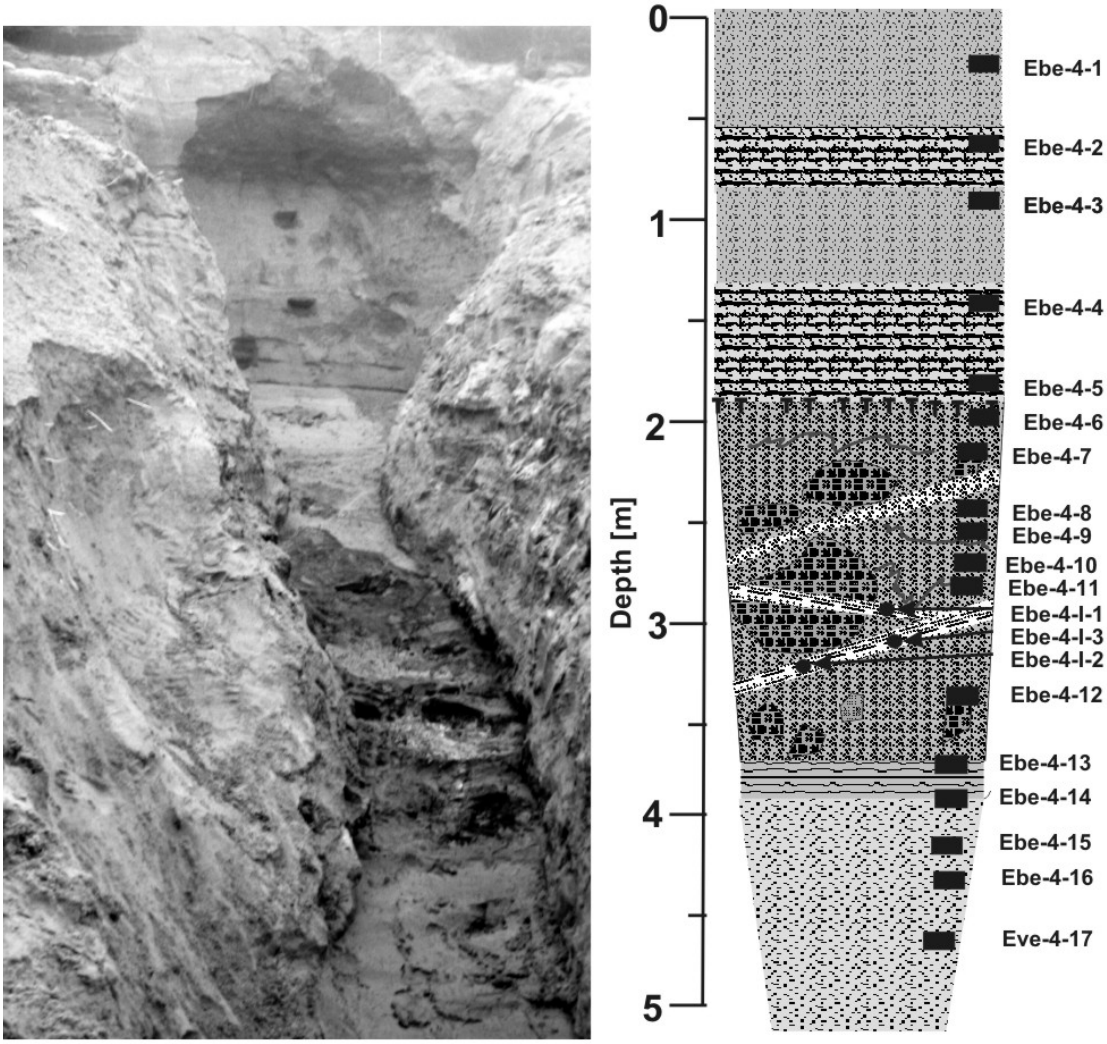



**Figure 4.5.2-1:** The sandy sequence of exposure Ebe-4 below the camp site

Between 5 to 4 m depths, spotty, yellowish-grey to brownish sand occurred without any visible sediment structure or cryostructure (samples Ebe-4-17 to 4-13; ice content 20-24 wt%). Between 4.00 to 3.50 m depth, angular, dark-brown, frozen peat fragments are incorporated into sandy frozen sediments (sample Ebe-4-12). It could possibly be a reworked fossil-horizon or refrozen peat material that was accumulated into a wave-cut notch in the banks of the Arynskaya Channel. Between 3.50 and 2.00 m depth level more peat inclusions were visible within frozen, yellowish sand (samples Ebe-4-11 to 4-6) but these inclusions are not as angular as below. This peaty-sandy layer featured two and 5 cm wide stripy ice-sand veins (samples Ebe-4-I-1 to 4-I-3) at 3.20 to 3.35 m depth as well as a sand-filled frost crack at 2.60 m. In addition, two horizons showing signs of cryoturbation structures occurred at 2.20 and 3.00 m depth. Two soil horizons of about 1 m thickness were observed above the permafrost table at 2.00 m depth. Each of this soil was characterised by a lower part featuring distinct bands (Figure 4.5.2-1).

#### 4.5.2.2 Exposure Ebe-2 (72.929°N, 123.608°E)

In order to investigate the lateral contact between sandy deposits of the “Arga Complex” type and the well known Ice Complex sequences of Ebe Basyn Sise Island, several trips were undertaken further to the south of Ebe Basyn Sise Island, on August 19 and August 31. Unfortunately no evidence of a contact between these two deposits nor any indication of the existence of Ice Complex deposits (such as thermokarst mounds) were found during these trips, although those were took place up to 10 km southwest of the camp. Nevertheless, the investigated exposures will be used for paleo-environmental reconstruction and therefore have to be presented in this report.

The exposure Ebe-2 was dug on the western slope of a hill, which was at first thought to be a Yedoma-topographic high. The hole dug in the ground exposed an about 1 m deep sedimentary profile The lower part of the profile was frozen and featured an horizon of greyish fine-grained sand (samples Ebe-2-1, 2-2; ice content ca. 19 wt%). Within this horizon a 5 cm thick ice layer of unknown origin was also observed (Figure 4.5.2-2). The ice features parallel striped horizontal structures as well as vertical needle-like crystals (samples Ebe-2-I-1 to 2-I-4). Above the permafrost table we observed a 15 cm thick layer of unfrozen well-bedded grey sand (sample Ebe-2-3) and a brownish-grey, non-bedded, silty fine-sand that contained vertical grass roots (sample Ebe-2-4). Further up a 25 cm thick rooted and cryoturbated brownish soil horizon (sample Ebe-2-5, 2-6) contained a lot of plant remains. Finally the top of the profile exposed a 5 cm thick, grey and dry fine-sand layer of probably eolian origin.

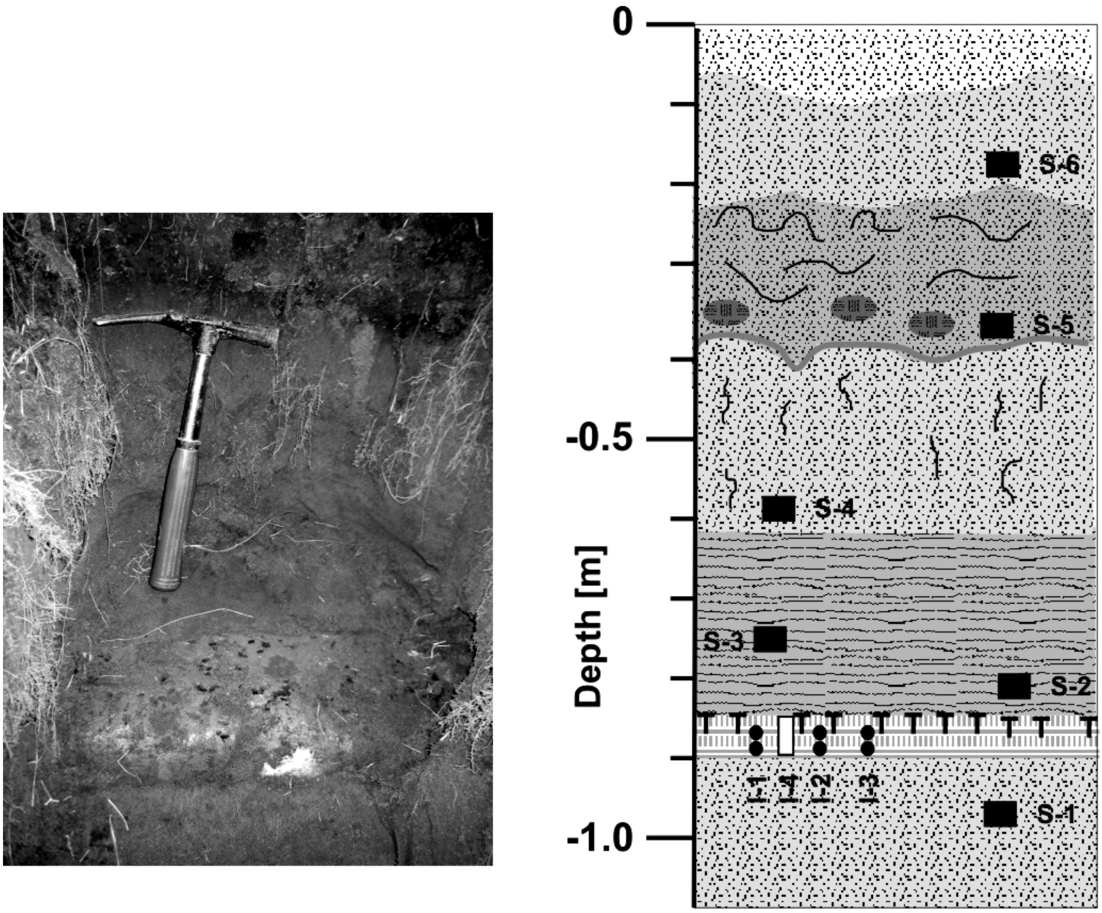
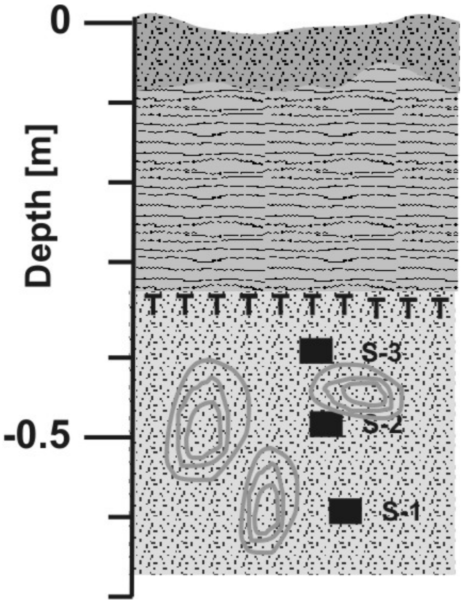



**Figure 4.5.2-2:** Exposure Ebe-2; Sandy soil sequence with segregation ice layer bear the permafrost table

### 4.5.2.4 Exposure Ebe-3 (72.927°N, 123.608°E)




The 60 cm deep profile Ebe-3 (Figure 4.5.2-3) was dug in the same area into a hill slope to the east of a thermokarst lake. The small hole exposed frozen greyish-brown fine sand with concentric rings of iron oxide impregnation between 30 and 60 cm depth (samples Ebe-3-1 to 3-3, ice content 25-30 wt%). Above the permafrost table unfrozen, greyish fine sand, containing small brownish bands and a cryoturbated brown horizon forms the modern soil layer.

**Figure 4.5.2-3:** The exposure Ebe-3

### 4.5.2.4 Exposure Ebe-5 (72.92 °N, 123.68 °E)

On the right bank of a small channel flowing parallel to the Utyan Uyesya Channel, an about 6 m high cliff was studied by T. Kuznetsova and V. Kunitsky on August 31. Two subprofiles were dug, which exposed the similar sandy sequence of frozen and unfrozen sands with lattice-like ice structures (Figure 4.5.2-4) mentioned in section 4.5.1. Undulate-bedded, fine to middle-grained, grey and frozen sand was exposed 3 m above water level (samples Ebe-5-1, 5-2). Just below the permafrost table a 5 cm thin ice vein was visible (sample Ebe-5-I-19), and was connected on the left hand side of the profile with a 30 cm wide ice wedge (sample Ebe-5-I-2). The horizontal ice vein was horizontally striped and contained a lot of gas bubbles. Unfrozen, well-bedded fine to middle grained sand occurred above the permafrost table, and was sampled up to 5 m above water level (samples Ebe-5-3 to 5-6).

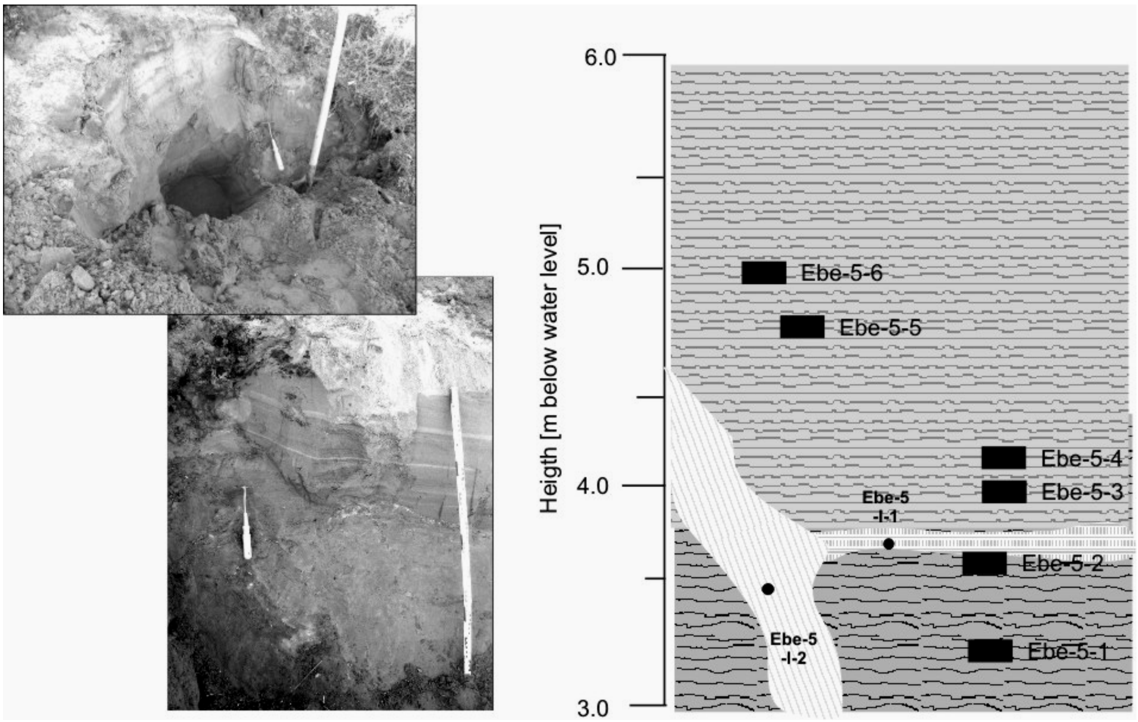



**Figure 4.5.2-4:** The combined profile of the Ebe-5 exposure

### 4.5.3 Sand and Ice Complex sequences of Khardang Island

*Lutz Schirrmeister, Viktor Kunitsky, Tatyana Kuznetsova, Guido Grosse*

As mentioned in chapter 4.5.2, the stratigraphic relation between the so-called "Arga-sands" of the 2nd terrace and the sandy units that underlain the Ice Complex deposits (3rd terrace) is still unknown. For this reason, a permafrost sequence located on the northwest coast of Khardang Island (3rd terrace, Figure 4.1-2, Figure 4.5.3-2) was studied. The site was reached by motorboat trips between August 25 and 30. For practical reasons, the investigation of the stratigraphic column between the beach level and the 20 m high top surface of the island was subdivided in several sub profiles exposed in thermokarst mounds (Baydzherakhs).

In general, the permafrost sequence consists of four different units (from bottom to top): 1) the lower sand unit up to 5 m height, 2) a 1 to 2 m thick peat horizon, 3) a peaty sandy transition zone (about 1.5 m thick) and 4) the Ice Complex unit (Figure 4.5.3-1).

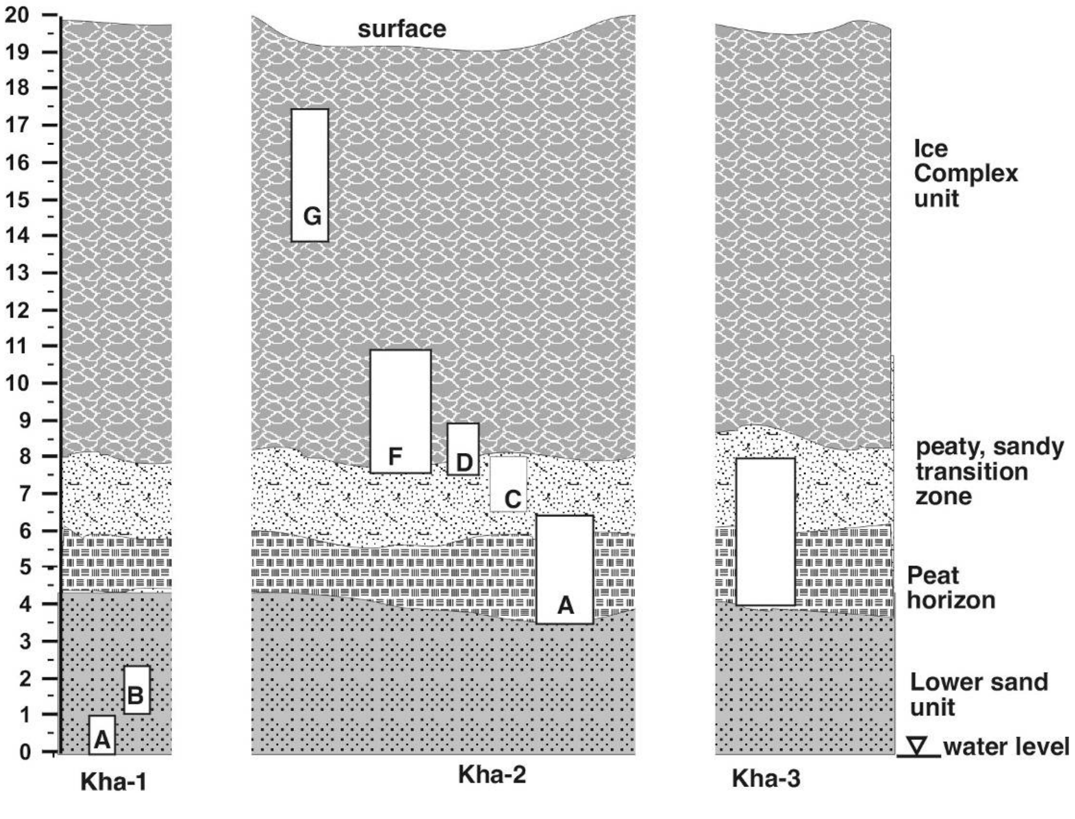
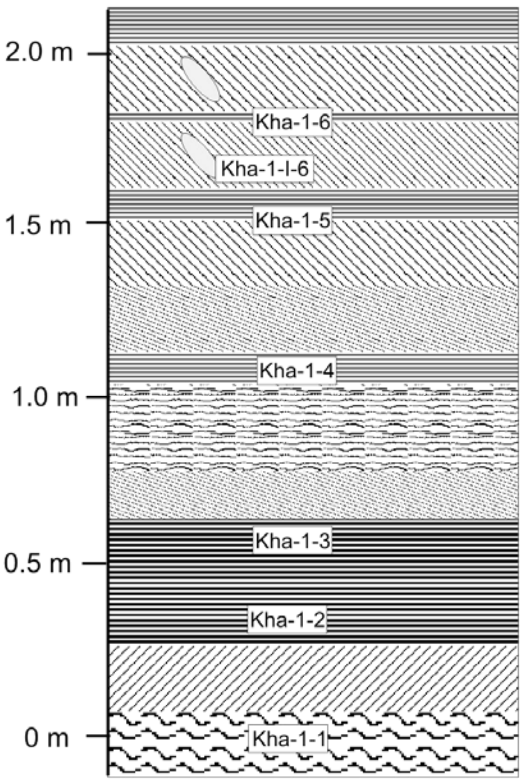



**Figure 4.5.3-1:** Schematic overview of the studied cliff sequence on Khardang Island and the position of the subprofiles

**Figure 4.5.3-2:** The studied cliff section with thermokarst mounds in northwest Khardang Island

### 4.5.3.1 The sand deposits in the exposure Kha-1

The lower part of the cliff is mostly constituted of a mix of horizontally- laminated and cross bedded layers. The sediments are mostly middle to fine-grained frozen sands with silty interbeds. The exposed part of this sandy layer was estimated to be approximately 8 to 10 m thick. Two subprofiles were investigated in this unit between 0 and 2.5 m above water level (samples Kha-1-1 to 1-6, Figure 4.5.3-1). The gravimetric ice content is relatively low and amounts 24 to 32 weight %. Two samples were collected for luminescence dating at 2.5 m and 7 m heights above water level (Kha-OSL-1, Kha-OSL-1). We noted the occurrence of cracks filled with small ice crystals within the frozen sandy deposits (Figure 4.5.3-3, sample Kha-1-I-1)



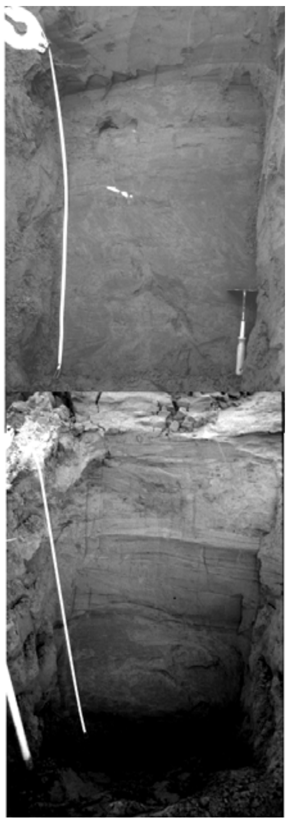



**Figure 4.4.3-3:** The sand profile Kha-1 near the beach level of the Arynskaya Channel

### 4.5.3.2 The sequence Kha-2

A peat horizon extends in about 5 to 7 m height above the river level along the studied cliff section. This horizon and the covering sediment were studied in several subprofiles of the exposure Kha-2 (Figure 4.5.3-4).

**Figure 4.5.3-4:** Thermokarst mound with Kha-2 subprofile exposures of the Arynskaya Channel cliff

At first sight, the peat horizon appeared to be continuous. However a closer look at the **Kha-2A** exposure revealed that its structure was far more complex The lowermost layer of 1.5 m thickness consists of peat fragments (clasts) within fine-laminated, greyish-green, fine-grained sand (samples Kha-2-1 to 2-4, gravimetric ice content 25 to 55 wt%). The next layer above is thin and sandier, and shows evidence of slumping structures (sample Kha-2-5, 2-6). A 0.5 m thick frozen moss-peat layer was observed further up (samples Kha-2-7 to 2-10, ice content 105 wt%). This layer probably reflects autochthonous accumulation conditions. The peat layer was additionally sampled at two heights for U/Th-dating (samples Kha-U/Th-1 to -5).

Overlying the peat is a greyish-brown cross-bedded sand (sample Kha-2-11). Further up, the strongly disturbed sediment structures probably indicate refrozen slump material. For this reason the upper part of the subprofile Kha-2A was not sampled.

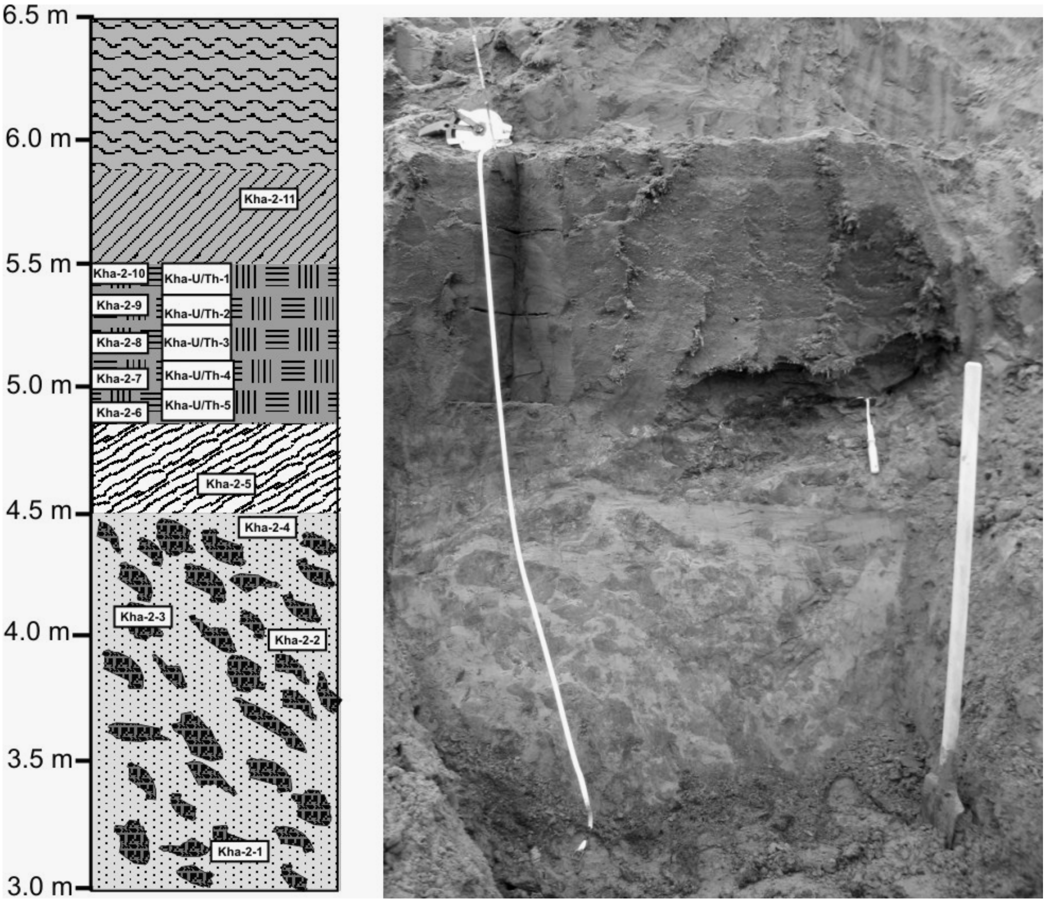



**Figure 4.5.3-5**: The subprofile Kha-2A (Khardang Island, Arynskaya Channel)

Between 6.6 and 7.5 m above water level, the subprofile **Kha-2C** (Figure 4.5.3-6) exposed thin (5-15 cm wide), lattice-like intersecting ice wedges (samples Kha-2-I-1 to I-4), and similar to those that were observed within the "Arga-sands" (Figure 4.5.3-6). The ice wedges consist of parallel and alternating ice and sand bands (so-called polozatiks). A larger peat inclusion on the left hand side (sample Kha-2-13) was covered by greyish fine sand (samples Kha-2-12, 2-14) containing the ice wedges. Above the ice wedges, a yellowish-grey silty fine sand showed sloping parallel structures (Kha-2-15).

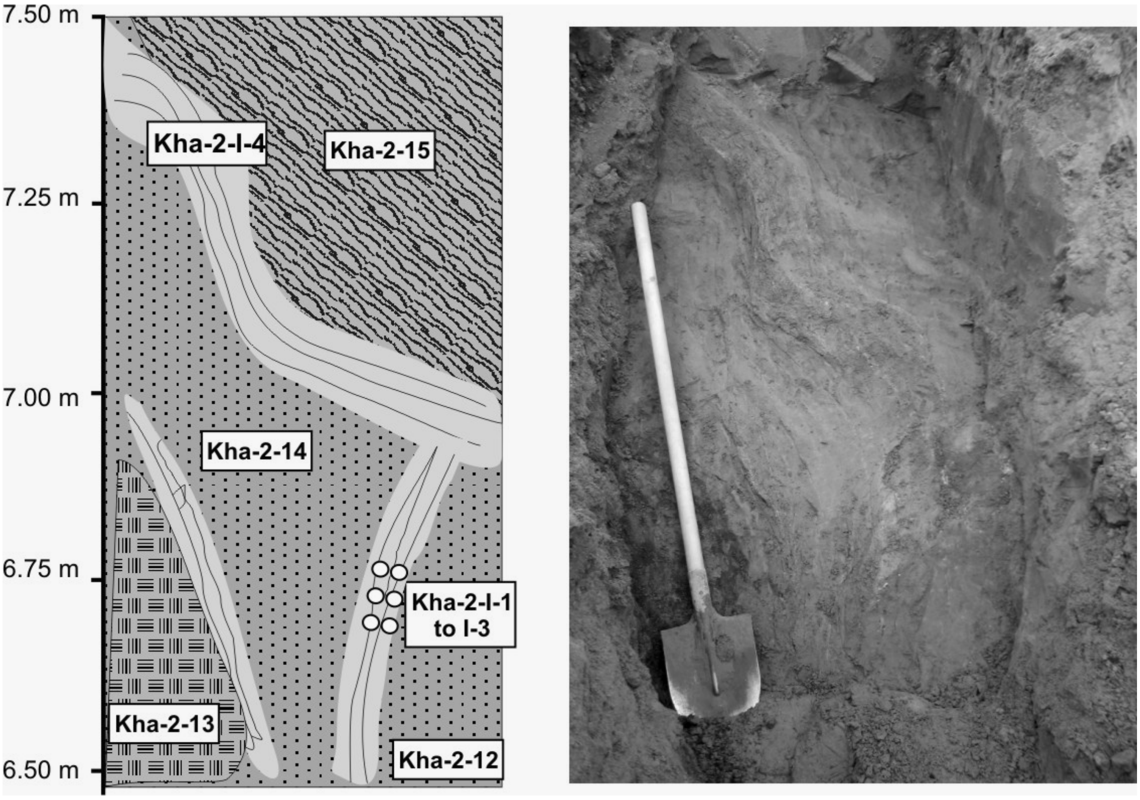



**Figure 4.5.3-6**: The subprofile Kha-2C, featuring a small ice wedge

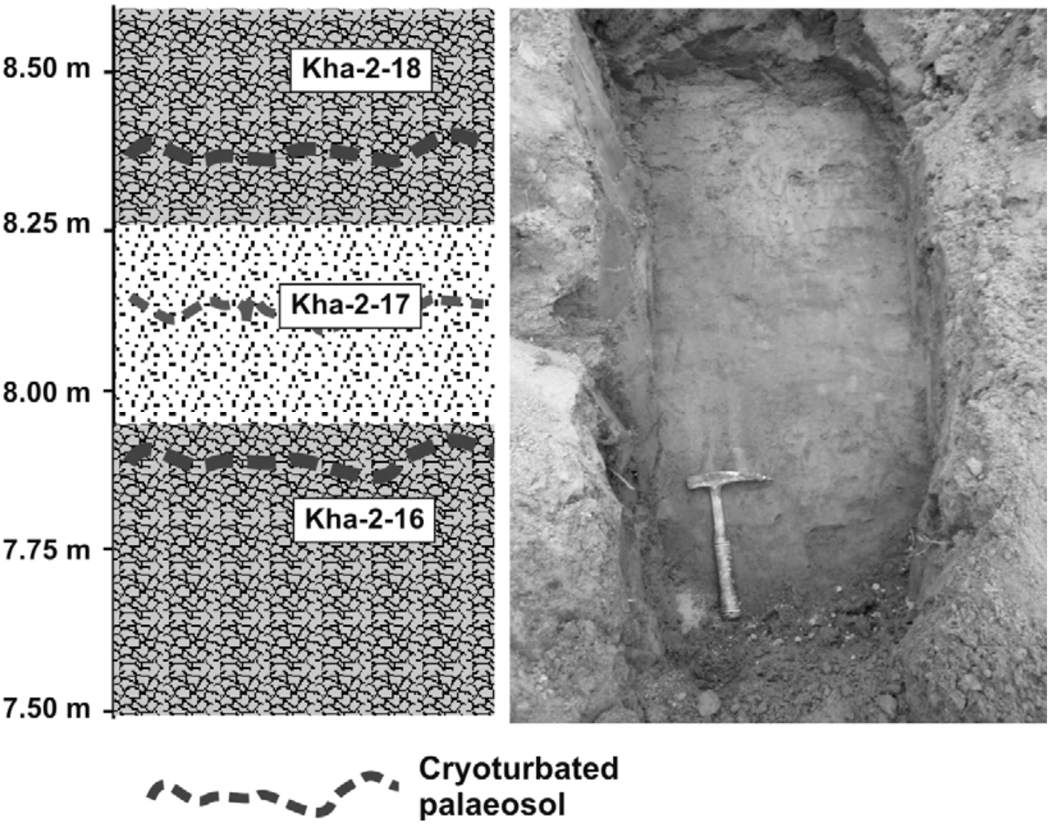



**Figure 4.5.3-7**: Ice Complex deposits of the subprofile Kha-2D

The next subprofile to the top **Kha-2D** (Figure 4.5.3-7) probably exposed the lower part of the Ice Complex sequence. This subprofile consists of two layers featuring ice-rich dark greyish-brown silty fine sand (aleurite) with banded cryostructures (samples Kha-2-16, Kha-2-18, gravimetric ice content 38 to 44 wt%), that alternate with greyish-brown sand with ripple-bedding (Kha-2-17, ice content 26 wt%). The layers contained weakly developed cryoturbated palaeosols.

Similar deposits were observed up to 11 m above water level. Ice-rich greyish sand (0.1-0.3 m thick) containing twig fragments, ice bands, and lens-like broken cryostructures are interbedded by light-grey to brownish sand layers (about 0.2 m thick). Huge ice wedges are typical in Ice Complex formation (Figures 4.5.3-2 and 4.5.3-4), but could not be excavated at this exposure. However the presence of thermokarst mounds indicates the existence of such ground ice bodies.

The subprofile **Kha-2F** (Figure 4.5.3-8) is a typical Ice Complex sequence and lies directly above the subprofile Kha-2C (Figure 4.5.3-1). The lower layer, featuring 0.2 m thick yellowish green sand (sample Kha-19) matches the upper part of the Kha-2C subprofile (sample Kha-2-15). Greyish ice-rich and organic-rich fine sand with lens-like reticulated and banded (0.5 to 5 cm thick) cryostructure occurred between 7.7 to 10 m above water-level (samples Kha-2-20 to 2-23, gravimetric ice content 47- 96 wt%). A cryoturbated palaeosol of about 0.5 m thickness with peat inclusions overlain the latter (sample Kha-2-24, ice content 23 wt%). Greyish ice-rich sediments similar to the ones mentioned above are found in the upper part of the sediment profile (samples Kha-2-24 to -27, gravimetric ice content 50 - 92 wt%).

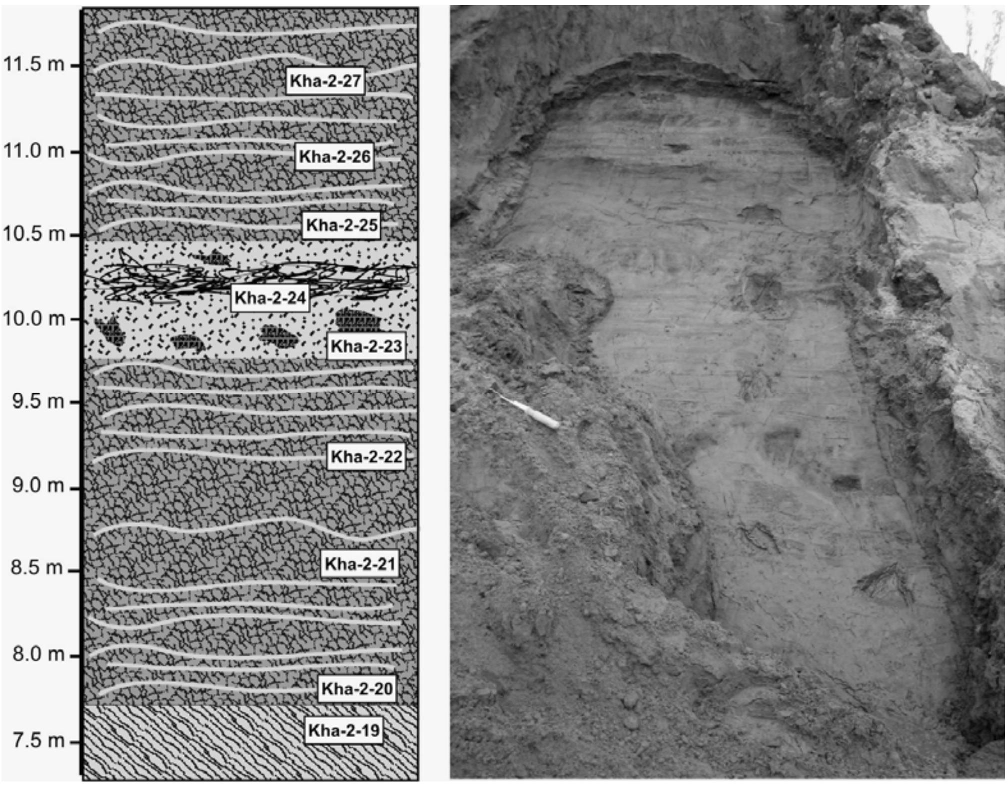



**Figure 4.5.3-8**: Ice Complex deposits at the subprofile Kha-2F

The uppermost subprofile, **Kha-2G,** consists of several alternations of ice-rich, ice-banded silty fine-sand layers. Several lens-like reticulated cryostructures and ice-poor palaeosol horizons with peat inclusions can also be observed (Figure 4.5.3-9). The gravimetric ice content ranged between 50 and 115 wt%.

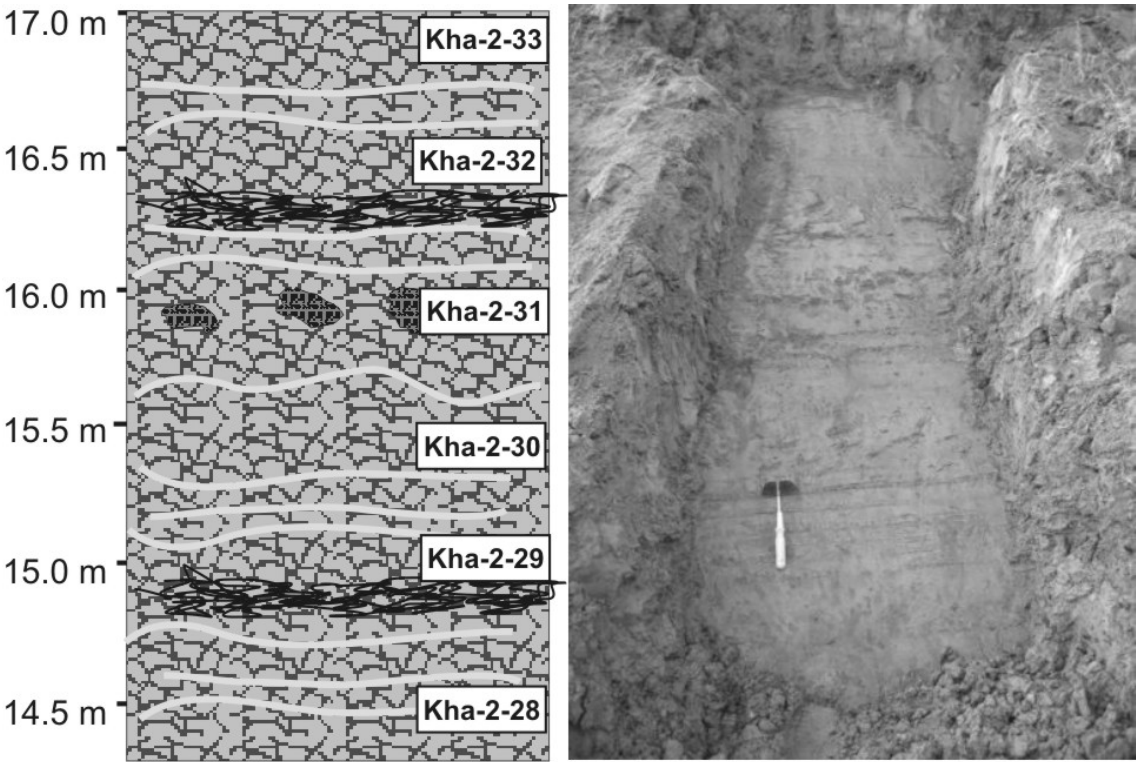



**Figure 4.5.3-9**: Ice-rich deposits of the uppermost subprofile Kha-2G

### 4.5.3.3 Exposure Kha-3: large ice wedge and surrounding sediments

A larger ice wedge was accessed within a small narrow thermoerosional valley (Ovrag) about 300 m north from the exposure Kha-2. The ice wedge was cleaned and sampled for isotope studies at different levels using ice screws and a small axe (samples Kha-3-I-1 to I-11). The ice wedge was exposed at the southern valley slope, and occurred within a sandy horizon (Figure 4.5.3-10). The lowermost part consists of yellowish-grey fine sand (sample Kha-3-1). Further up, the ice wedge traverses a peat layer (Kha-3-2, 3-3) similar to those of the subprofile Kha-2A. The higher part of the section is made of greyish, fine sand with numerous brownish and blackish spots together with small twig fragments (sample Kha-3-4). The actual ice wedge thickness amounts to about 0.5 m. Ice belts concavely bent towards the ice wedge reflect syncryogenetic ice wedge formation. The ice wedge is striped with alternating 0.5 to 2 cm wide sand and ice stripes (Figure 4.5.3.-11). Its volumetric sand content was visually estimated to be 40 %. Such striped sand-ice wedges are termed “Polozatic”.

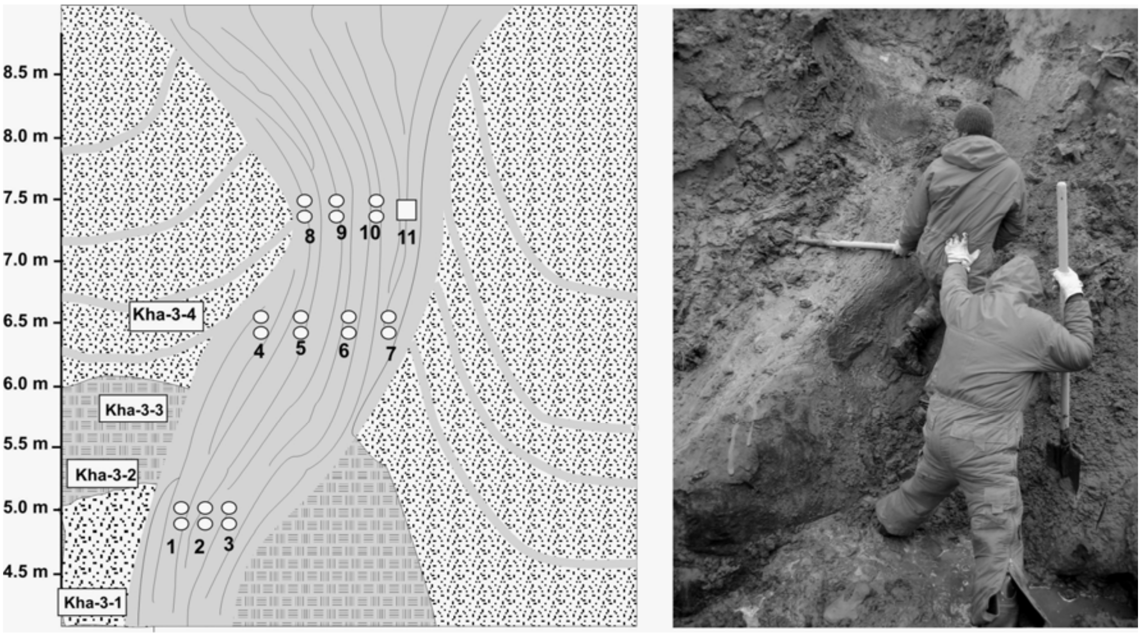



**Figure 4.5.3-10:** Ice wedge within peat and sand deposits at the Kha-3 exposure

**Figure 4.5.3-11:** Stripped ice structure (vertical silt-ice stripes) in the ice wedge Kha-3

## 4.6 Subsurficial and Bathymetrical Ground Penetrating Radar (GPR) Investigations

*Hugues Lantuit and Waldemar Schneider*

A series of Ground Penetrating Radar (GPR) transects were undertaken in order (1) to map subsurficial ground stratigraphical features in the vicinity of investigated exposures and/or boreholes and (2) to map the bathymetry of the Arynskaya Channel.

### 4.6.1 Subsurface mapping of the Arga sands stratigraphical unit

The Arga sands formation deposition was presumably associated with a “high accumulation rate implied by a fluvial environment under upper flow regime” (Schwamborn, 2002). As highlighted in previous studies (Schwamborn et al., 2000) it implies complex stratigraphical interpretations, associated with age inversions within the stratigraphical columns of cores extracted from the Arga sands (Krbetschek et al., 2000). The nature of sedimentary processes at the time of deposition can be partly deduced from the morphometric characteristics (i.e. height, width, inclination) of sub-units within the stratigraphical column. However, those can hardly be captured by borehole and exposure investigation which are either strictly limited to a pre-established instrumental width (e.g. the mean diameter of collected cores in section Tur-2 is 6 cm) or by the inconspicuous nature of surrounding slopes in exposures which are often covered with sloping degraded material from the upper sub-units. Schwamborn et al. (2000) showed that GPR transects, undertaken in the Arga sands formation could reveal the nature of sediment bedding in the upper decameters and thereafter provide a further insight into the nature of deposition processes. In return, if GPR transects are operated immediately above investigated boreholes/exposure, collected sedimentological investigations on core and/or exposures will yield crucial information to the calibration/validation of GPR results, namely medium permittivity and velocity values. Therefore, a series of GPR transects was undertaken in late summer 2005 to aid interpretation of the boreholes and exposures described in the chapters 4.5.1.1 and 4.5.2.1. The location of these transects is shown in figure 4.6-1.

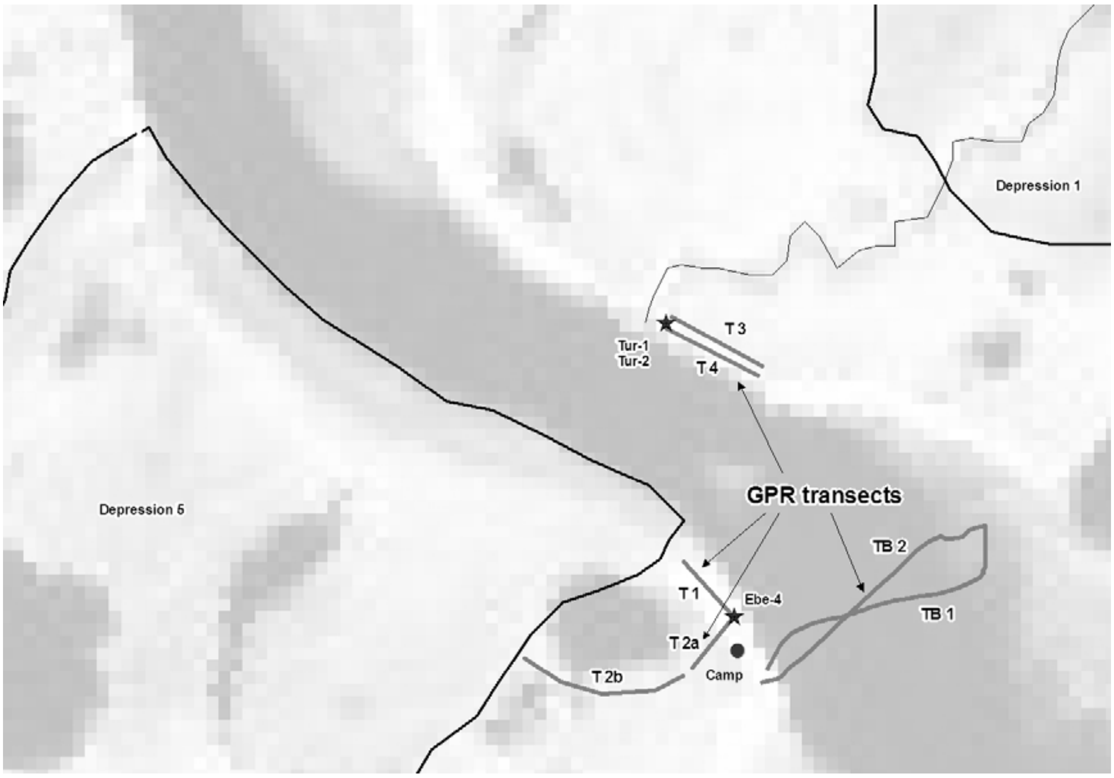



**Figure 4.6-1:** Distribution of transects on Ebe-Basyn-Sise and Turakh Sise Islands and location of corresponding exposures/boreholes investigated during the course of the Lena 2005 expedition.

### 4.6.1.1 GPR survey configuration

The impulse radar device used for the survey was a RAMAC/GPR System, which consists in integrated control unit, field PC and 50 and 200 MHz antenna units containing both transmitting and receiving antennas (Figure 4.6-.2). The control unit generates time cycles to switch on and off the transmission of impulses by the transmitter and synchronizes these sequences with the receiver. All operations were handled by the operator(s) in the field on a Husky PC equipped with the appropriate software. Each trace was manually collected by the operator(s) by pressing the “record” key. A pre-determined sampling length interval was used to translate these measurements into distances. However, due to the irregular topography of the tundra surface, and the subsequent modification of the operator’s pathway, we can assume the occurrence of small to large errors (i.e. up to 50% of the sampling length interval) during surveys. Therefore, distances between mark points (including start and end points) along the survey transect were measured in the field in order to correct for this error. The type of antenna (i.e. its frequency) as well as the general settings for data collection is described in the following sections for each transect. A summary of these settings is listed in table 4.6-1.

**Table 4.6-1:** GPR transects settings

| Transect name | Antenna frequency (MHz) | Sampling frequency (MHz) | Time window (ns) | Number of stacks | Antenna separation (m) |
|---|---|---|---|---|---|
| T1 | 50 | 545 | 917 | 32 | 4.0 |
| T2a | 50 | 545 | 917 | 32 | 4.0 |
| T2b | 50 | 545 | 917 | 32 | 4.0 |
| T3 (1) | 50 | 552 | 906 | 32 | 4.0 |
| T3 (2) | 50 | 355 | 881 | 32 | 4.0 |
| T4 (1) | 50 | 401 | 998 | 64 | 4.0 |
| T4 (2) | 50 | 553 | 906 | 64 | 4.0 |
| TB1 | 200 | 1173 | 551 | 16 | 0.6 |
| TB2 | 200 | 1234 | 799 | 16 | 0.6 |

**Figure 4.6-2:** Set-up of the GPR system above exposure Tur-1. The antennas are towed behind the operator who carries the control unit and the PC unit.

### 4.6.1.2 Transects at exposure Ebe-4 (72.965°N, 123.807°E)

Two intersecting transects were surveyed at Ebe-4 with the 50 MHz antennas (see Figure 4.6-1). The intersecting point for the two transects was located just above the 6 m high exposure. Transect 1 was traced along the top of the shore cliff and Transect 2 roughly perpendicular to the Transect 2 landwards. Transect 2 was operated in two parts. The first part (Transect 2a) was kept straight and traces were recorded over a 120 m distance. The second part (Transect 2b) corresponds to the extension of Transect 2b landwards along a non-straight path. Transect 2b was meant to be acquired over two distinct morphological units, namely the shore of the river and the thermokarst depression (Alas) located about 500 m inland from the Ebe-4 exposure. The reader is referred to figure 4.6-1 for further explanation. Transect 1 was surveyed several times using different sampling settings (see Table 4.6-1) while Transect 2 was run one time using fixed settings. One of the resulting profiles is shown in figure 4.6-3

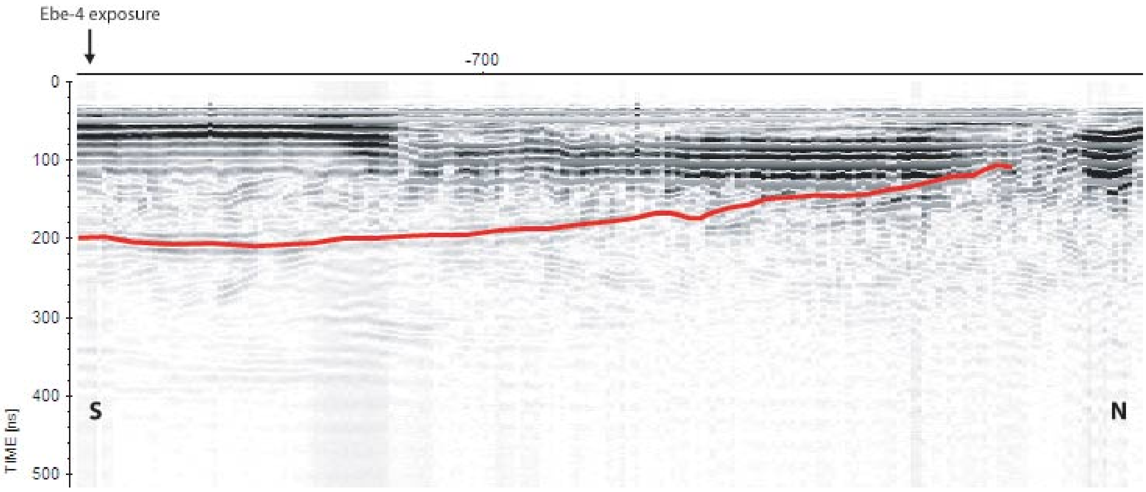



**Figure 4.6-3:** Close up on the southern section of transect 2a. Obvious stratigraphic interfaces are highlighted using solid lines

### 4.6.1.3 Transects at exposure/borehole Tur-1/Tur-2 (72.97408° N; 123.79858°E)

Two transects (3 & 4) were surveyed on the opposite side of the Arynskaya Channel, in order to correlate GPR measurements with stratigraphic information from Tur-1 and Tur-2. The two transects were performed using similar settings over two parallel transect lines. The first transect was undertaken at the top of the cliff overlooking the Arynskaya Channel, while the second transect was done on the narrow sandy strip at the foot of the cliff. Sampling settings are reported in table 4.6-1.

### 4.6.2 Arynskaya Channel bathymetry

The Arynskaya Channel is located in the western part of the Lena Delta. It is the second in importance in this part of the Delta after the Olenekskaya Channel. It begins at a confluent with the Olenekskaya Channel approximately 100km to the north-west of the delta apex. It then flows between Kyuryuelyakh-Sise Island and Khardang Island on the southern side and Turakh-Sise on the northern side until one branch merges with the Olenekskaya channel in the area of the Olenekskaya channel mouth (*Utya Uyesya Channel*) while the other branch bifurcates to the north, dissecting the Arga sand stratigraphic unit and finally forming a small estuary at its exit to the sea (Cape Cherkannakh-Tumsa). Its mean annual water discharge is believed to be small in relation to the other delta channels. It is thought to catch only a small part of the mean annual water discharge of the Olenekskaya Channel, which represents itself only 6.8% of the total mean annual water discharge of the Lena Delta (Pavlova and Dorozhkina, 2000). Thus, relatively to the other channels in the Lena Delta, the Arynskaya Channel is poorly studied because of its presumed low significance in the hydrologic system and sediment budget of the Lena Delta (Rachold et al., 2000). There is actually no current high resolution source of information on the channel's bathymetry (D. Bolshiyanov, personal communication, 4.9.2005).

Further knowledge on the Arynskaya Channel's morphometric characteristics is however necessary to the understanding of the Arga sand complex, since it is the only channel of importance to dissect this stratigraphical unit. The time of installation of the Arynskaya Channel in its current bed that is through the Arga sand complex, is largely speculated and a precise assessment of its morphometry can serve several purpose, including the reconstruction of its chronology. While subaerial morphometric characteristics can be drawn from air- or space-borne imagery, its bathymetry must be recorded in the field.

A GPR survey was therefore run to map the channel´s bottom surface across the western-most branch of the Arynskaya Channel. For technical details on the RAMAC GPR unit the reader is referred to section 4.6.1.1. An experimental survey configuration was installed in a small rubber boat (2,5m x 1m) towed behind a motorized “zodiac”-type boat (Figure 4.6-4).

**Figure 4.6-4**: experimental setup of the GPR antennas in a rubber boat towed behind a motorized boat.

The configuration consisted of a pair of 200 MHz antennas mounted in the boat with the axis transmitter-receiver parallel to the boat direction. The operator was installed in the small rubber boat in order to provide sufficient weight against potential wave action and to proceed to manual recordings of pulse traces. The position of the boat across the channel was permanently monitored from the shore by triangulation and additional points were acquired from the motorized rubber boat by echosounding (see chapter 4.3 for technical details on echosounding bathymetry) to provide a source of calibration/validation for the GPR profile. Two transects were successfully surveyed across the branch and are shown on figure 4.6-1

Correction/validation of the GPR datasets was done using typical values for water relative permittivity and velocity. Two different sets of sampling parameters were used for the two transects and are listed in table 4.6-1. One of the resulting 2D profiles is shown in figure 4.6-5. The bottom floor is easily identifiable on the filtered profile. It reaches a maximum depth of approximately 5.6 m and is characterized by three main morphological elements:

1. A very shallow (< 1.0 m) and flat zone located next to the shore and featuring a secondary reflector located approximately 0.5 m below the channel bottom floor, 2. a zone characterized by depths ranging between 1.0 and 4.0 m with a fairly inhomogeneous topography and 3. a narrow and deep (5.6 m) zone surrounded by steep underwater levees (~ 2.0 m deep).

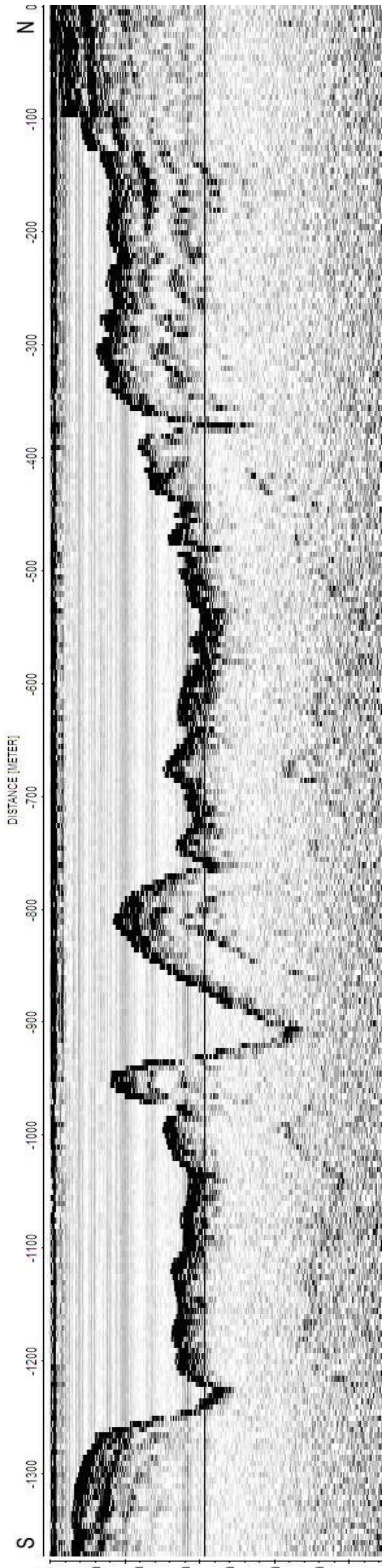



**Figure 4.6-5:** S-N bathymetric profile (TB2) of the Arynskaya Channel. Depths marked in meters are calculated using a 0.033 m/ns velocity for water.

## 4.7 Measuring of local weather and soil conditions by soil probe and weather station

*Guido Grosse and Lutz Schirrmeister*

During the field season almost continuous loggings of soil temperature and soil moisture were conducted with a soil probe at sandy site in the vicinity of the camp at Ebe-Sise Island. The main vegetation consisted of grass, and the soil surface was slightly tussocky. The soil probe sensors were fixed in 5 cm depth. The measurement interval was 5 min. The logging lasted from 22nd August to 31st August 2005. The breaks in the logging period are caused by failure of power supply for the probe. Table 4.7-1 shows the extreme values during the logging. Whereas the temperature shows diurnal variation and a slight decrease during the whole period (Figure 4.7-1), the logging of volumetric soil moisture showed an almost constant moisture content of 0.4 m3 x m-3 in the upper soil during the measurement period without diurnal variation.

**Table 4.7-1:** Values for in situ soil temperature and soil moisture (measured as electric soil voltage) logged with a soil probe in the upper 5 cm of a sandy site near the camp

| | Min | Max | Mean | Sd (+/-) | Logged values |
|---|---|---|---|---|---|
| Soil temperature | 0.38 °C (24-08-04) | 7.94 °C (13-08-04) | 3.31 °C | 1.88 | 1978 |
| Volumetric soil moisture | 0.14 $m^3$ x $m^{-3}$ | 0.32 $m^3$ x $m^{-3}$ | 0.24 $m^3$ x $m^{-3}$ | 0.03 | 1978 |

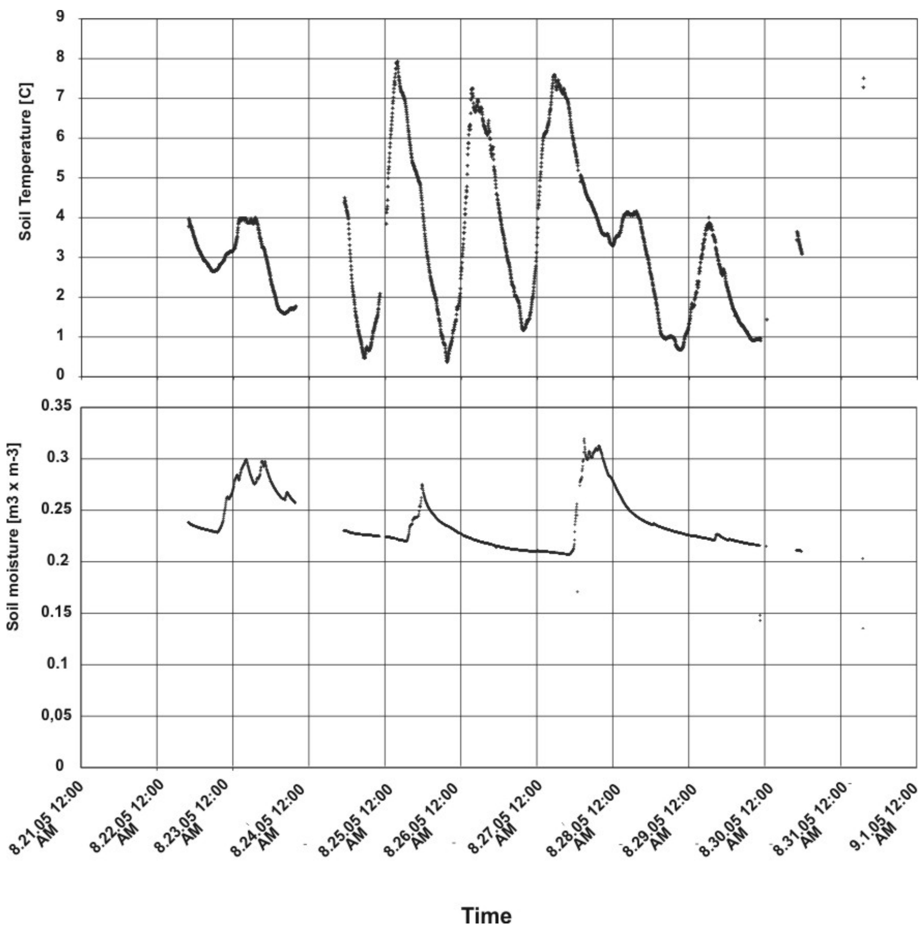



**Figure 4.7-1:** Diurnal variations in soil temperature within the upper 5 cm of an Edoma surface

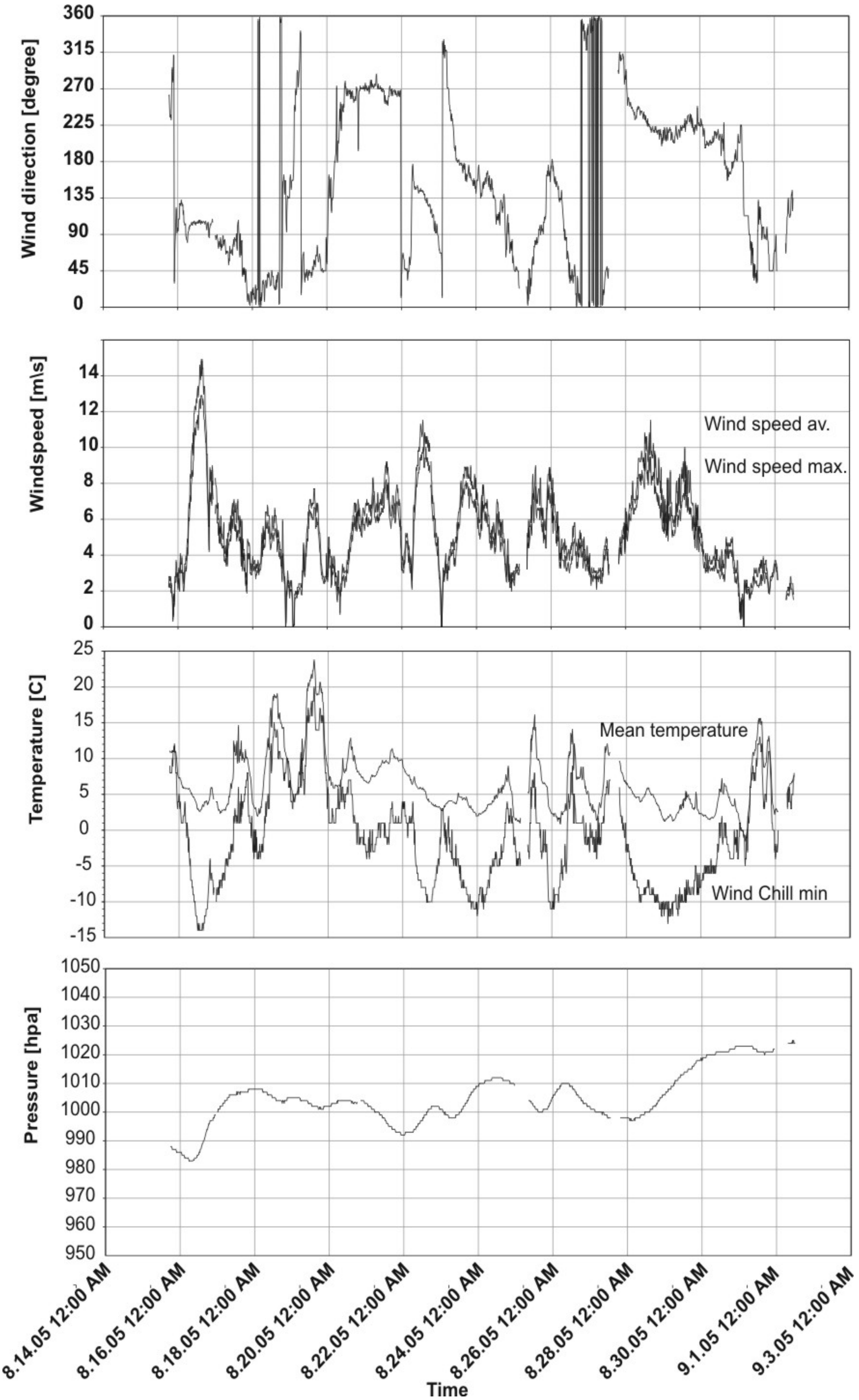



**Figure 4.7-2**: Weather data of the expedition period on Ebe Sise Island

At the same place a small climate station was installed measuring wind orientation, wind speed, air temperature in 2 m height above surface as well as air pressure, wind chill temperature between 16th August and 1st September (Figure 4.7-2, 4.7-3).

**Figure 4.7-3:** Measuring site for soil probe and climate station near the camp.

## 4.8 Paleontological collection of the "Mammoth" fauna from the museum of the Lena Delta Reserve

*Tatyana Kuznetsova*

Remains of large Pleistocene mammals always attract attention. Scientists and local people who work and live in the Laptev Sea Region find and collect various bones and fragments of large mammals. Some of them are brought to the Lena Delta Reserve. Mammal remains of the "Mammoth fauna" are the most common artifacts in the paleontological collection of the Lena Delta Reserve museum. The collection includes single bones, fragments of skeletons, bones with soft tissues and hair of Late Pleistocene and Holocene specimens. It consists of nearly 300 samples.

The museum was created thanks to the enthusiasm of Dr. A. Gukov, the present director of the reserve. Employees of the reserve, school teachers, pupils and other interested people also contribute. The first specimens were collected in 1985. They were bison bones collected by Yarlykov Yu. A. on Makar Island (Yana Delta Region) near the Makar polar station; Efimov S. N. found horse and reindeer bones on the Myostakh Cape, Bykovsky Peninsula (Lena Delta Region). Mammoth and reindeer bones were collected by Gukov A. Yu. during the same year on Kurungnakh-Sise Island (Table appendix 4-6, Figure 4.8-2).

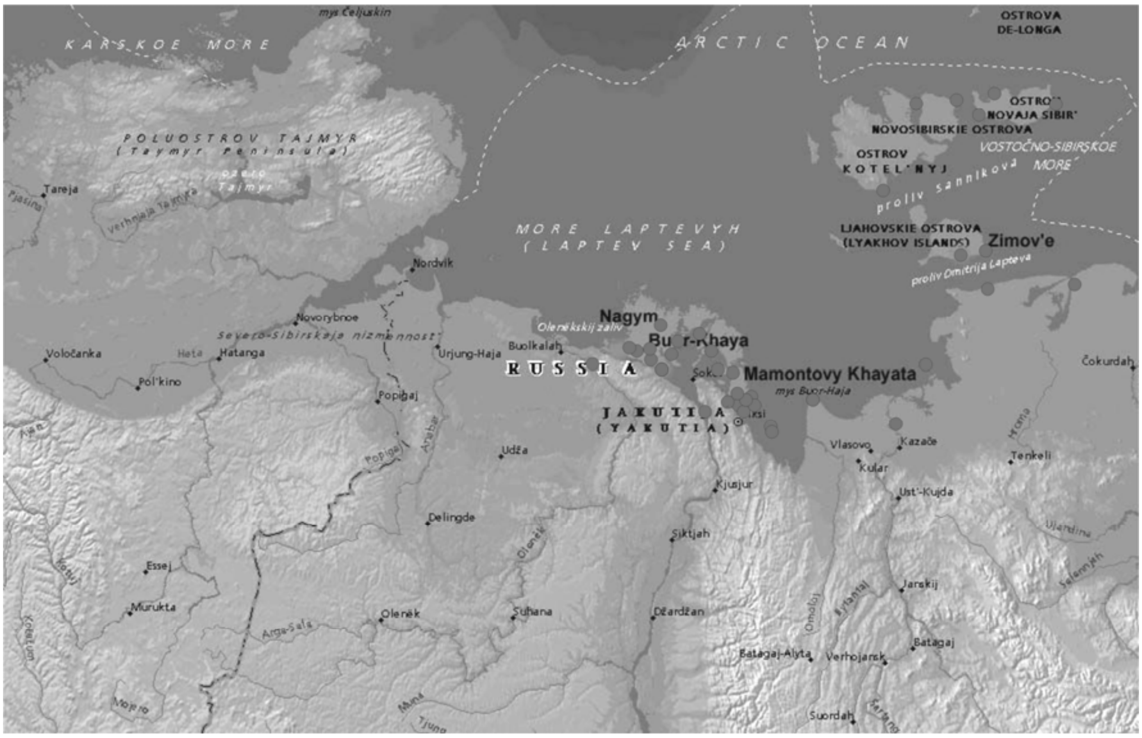



**Figure 4.8-1:** Collecting areas of the paleontological collection of the Lena Delta Reserve museum

Over more than 20 years many people have presented their finds to the reserve. These are samples from different islands of the Lena Delta Region, from the New Siberian Islands, from the Yana Delta Region, and from the southern coasts of the Laptev and East Siberian Seas (Figure 4.8-1). Most of the collection consists of bones from the Bykovsky Peninsula (about 100 samples) as well as from the islands of the Lena Delta Region. Unfortunately not all samples have exact information about their origins nor is geological information available for all finds. It is typical for this exhibition that the finds were collected by amateurs (not during geological or paleontological expeditions).

A considerable portion of the collection consists of finds of Dr. A. Gukov from different locations within the Lena Delta Reserve. In 2001 Dr. A. Sher delivered about 40 samples from the Bykovsky Peninsula (Mamontovy Khayata) to the museum (Table appendix 4-6).

**Table 4.8-1:** List of taxa of the paleontological collection of the "Mammoth" fauna from the museum of the Lena Delta Reservation.

Class MAMMALIA – mammals
Order Proboscidea
- *Mammuthus primigenius* (Blum). – woolly mammoth

Order Artiodactyla
- Family Cervidae
  - *Rangifer tarandus* (L.) – reindeer
  - *Cervus elaphus* L. – red deer
- Family Bovidae
  - *Bison priscus* (Boj.) – Pleistocene bison
  - *Ovibos moschatus* Zimm. – muskox

Order Perissodactyla
- Family Equidae
  - *Equus sp*. – horse
- Family Rhinoceratidae
  - *Coelodonta antiquitatis* (Blum.) – woolly rhinoceros

Order Carnivora
- Family Felidae
  - *Panthera spelaea* (Gold.) – cave "lion"
- Family Ursidae
  - *Ursus arctos* L. – brown bear

Near half of the collection (49.8%) are woolly mammoth bones usually leg bones (Figure 4.8-3), which is typical for an unspecialized collection. Remains of bison, horse and reindeer form 20.4%, 16.3% and 9.3%, respectively. 2.4% of the samples come from musk oxen (Figure 4.8-2). The collection has single specimens of woolly rhinoceros, caver "lion", bear and red deer (Table appendix 4-6. Table 4.8-1).

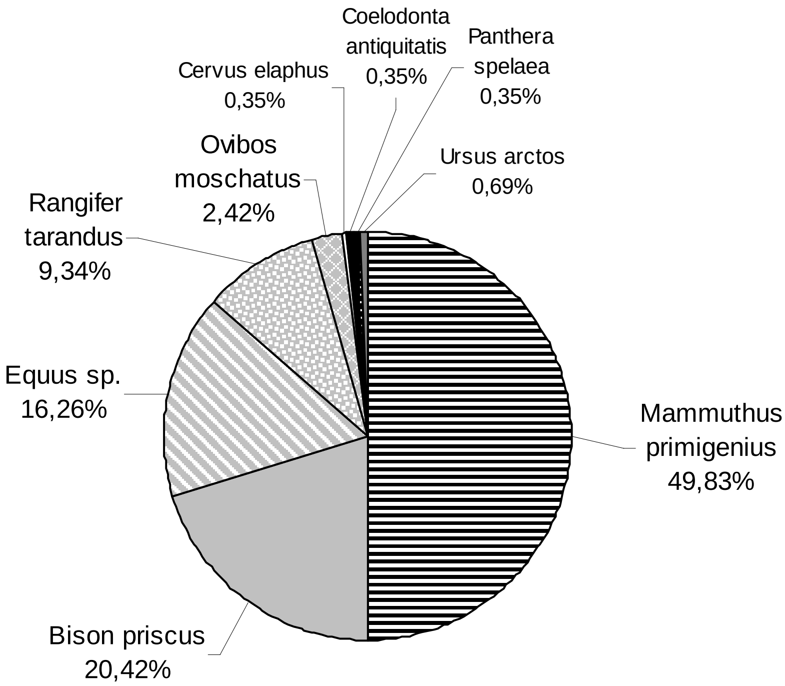



**Figure 4.8-2**: Composition of paleontological collection of museum of Lena Delta Reservation (total number - 292 specimens)

The museum collection contains rare and interesting samples.. Several bones of woolly mammoth had some well-preserved soft tissue (ligaments) and bone marrow inside them. There are two unique specimens – the skull and lower jar of a small mammoth and a fragment of the lower jaw of a baby mammoth. A damaged skull and lower jaw of a small woolly mammoth (LDR – O14-O15) were found S. Yu. Volkov in 2002 on Kurungnakh-Sise Island, Buor-Khaya (Lena Delta Region). The skull was restored from fragments and includes two teeth and small tusks. The fragment of the lower jaw of the baby mammoth (LDR – O50) has two milk teeth, which had not yet emerged. This specimen was very well preserved.

**Figure 4.8-3**: Different bones of *Mammuthus primigenius* from the Lena Delta Reserve museum collection.

**Figure 4.8-4**: Skull fragment of *Bison priscus* (LDR-O 271). It was found by N. V. Gukova on the Muostakh Cape, Bykovsky Peninsula (Lena Delta Region) in 2001.

**Figure 4.8-5:** Skull of *Equus sp*., very well-preserved (LDR-O 19), collected by A. Yakshina on the Rozhina Cape (New Siberian Island) in 2000.

**Figure 4.8-6**: Skull of male of *Ovibos moschatus*, very well-preserved (LDR-O 228). presented by S. E.Krasovskiy (Taimylyr village), in 1988.

The museum’s paleontological collection includes animal hair as well (Table appendix 4-6). There are several specimens of woolly mammoth hair of different colours and lengths. I. A. Yakshina, F. V. Sellyakhov and I. Mikolauskas collected them on Bol’shoy Lyakhovsky Island. Samples of woolly rhinoceros hair (LDR – P 71) from the Olenek region were presented to the museum by T. D. Krasovskaya.

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## 4. 10 Appendices

**Appendix 4-1:** Field spectrometry – description of Measuring (m.) points and profiles (see chapter 4.4)

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Samoylov (Sam1)/ 12.08.2005 / 11:40 126°28'40.66" E 72° 22' 1.56" N** | *Low-centre polygon at the uppermost accumulation terrace / Weather: varying to strongly clouded* | 000 / 001 | bareoptic / 24° | Polygon wall above, grass and moss | Point m. |
| | | 002 / 003 | bareoptic / 24° | Polygon wall middle (slope), moss and Salix sp. | Point m. |
| | | 004 / 005 | bareoptic / 24° | Polygon centre, wet, moss, sedge | Point m. |
| | | 006 / 007 / 008 | bareoptic / 24° | Polygon centre, sediment with vegetation, minor covering, moss, sedge, Salix sp. | Point m. / sunny |
| | | 009 / 010 | bareoptic / 24° | Polygon centre, sediment with vegetation in minor covering, less moss | Point m. |
| | | 011 / 012 | bareoptic / 24° | Polygon slope with moss and grass | Point m. |
| | | 013 / 014 / 015 | bareoptic / 24° | Polygon wall across a frost crack | Point m. / strong cloud variation |
| | | 016 - 020 | bareoptic / 24° | Profile across a polygon about from N to S | Profile m. |
| | | 021 - 025 | bareoptic / 24° | Profile across a polygon about from S to N | Profile m. |
| | | 026 - 029 | bareoptic / 24° | Profile across a polygon about from E to W | Profile m. |
| | | 030 - 033 | bareoptic / 24° | Profile across a polygon about from W to E | Profile m. |
| | | 034 / 035 | 8° | Salix sp.-shrub, about 15cm high, gray-green leaves and sporadic grass | Point m. |
| | | 036 / 037 | 8° | Area with moss (green-yellowish) and sporadic grass | Point m. |
| | | 038 / 039 | 8° | Sediment spot with sporadic grass and *Polygonum* sp. | Point m. |
| | | 040 / 041 | 8° | Area with grass, sporadic moss | Point m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Samoylov (Sam2) / 12.08.2005 / 16:30 / 126° 28' 43-43" E 72° 22' 8.18" N** | Polygon with pond, profile across the slope to the banya lake at the upper accumulation niveau | 000 / 001 | bareoptic / 24° | Polygon wall top grass, moss, sporadic Salix sp. | Point m. |
| | | 002 / 003 | bareoptic / 24° | Polygon slope, wetter underground, more moss, less grass | Point m. |
| | | 004 / 005 | bareoptic / 24° | Polygon centre covered, underground very wet, sedge, less moss | Point m. |
| | | 006 / 007 | bareoptic / 24° | Polygon centre, standing water, only sedge | Point m. |
| | | 008 / 009 | bareoptic / 24° | Polygon pond, ca.70cm deep, non covered | Point m. |
| | | 010 | bareoptic / 24° | White reference | |
| | | 011 - 012 | bareoptic / 24° | Profile from polygon wall to polygon centre, about 3-4m | Profile m. |
| | | 013 - 015 | bareoptic / 24° | Profile from polygon centre to polygon wall | Profile m. |
| | | 016 | bareoptic / 24° | White reference | |
| | | 017 - 040 | bareoptic / 24° | Profile from upper terrace (underground relative wet) across a dryer slope (2-3°) towards the banya lake, start: 126° 28' 41.99" E 72° 22' 8.61" N, en: 126° 28' 45.63" E 72° 22' 7.10" N<br>017 - 020 about 20m across one polygon to the next polygon centre<br>021 error<br>022 White reference<br>ca from 035 / 036 dryer slope area | Profile m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Samoylov (Sam3) / 12.08.2005 / 18:15** | Profile from the lower older to the higher terrace, Weather: diffuse sunny / Start: 126° 28' 29.03" E 72° 22' 12.54" N, End: 126° 28' 31.08" E 72° 22' 9.08" N | 000 | bareoptic / 24° | White reference | |
| | | 001 - 028 | bareoptic / 24° | 003 / 004 / 005 moss, wet | Profile m. |
| | | | | 008 Polygon wall, dry | |
| | | | | 010 / 011 moss, standing water | |
| | | | | 017 Polygon wall, moss | |
| | | | | 021 / 022 from the lower to the higher level, across a short, steep slope, relative dry | |
| | | | | 028 polygon wall at upper terrace | |
| **Island Samoylov (Sam4) / 12.08.2005 / ca.19:00** | Profile at niederer (episodischer) acrossflutungsterrace, Startpunkt: 126° 28' 23rd 34" E 72° 22' 13rd 47" N, Endpunkt: 126° 28' 18.95" E 72° 22' 13rd 87" N | | | Vegetation, sparse covered, cover range about 50%, sedge and *Salix* sp., in between non-covered dark-gray soil | |
| | | 000 | bareoptic / 24° | White reference | |
| | | 001 - 012 | bareoptic / 24° | 001 - 004 relative dry | Profile m. |
| | | | | from 005 about 5 cm deep stagnant water with up to 40cm high sedge | |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Kurungnahk (Bkh05) / 13rd 08.2005 / ca. 18:00, 126° 15' 22.57" E 72° 19' 15.88" N** | Bkh05c<br>Profile and point m.en in a drained active layerass lake of the 3rd terrace,<br>Weather: varying clouded with sunny periods | | | Vegetation: relative high grass and *Salix* sp. shrubs | |
| | | 000 / 001 | bareoptic / 24° | Sediment | Point m. |
| | | 002 / 003 | bareoptic / 24° | Grass | Point m. |
| | | 004 / 005 | bareoptic / 24° | Grass | Point m. |
| | | 006 / 007 | bareoptic / 24° | *Salix sp.*-shrub 60-70cm high, underneath grass | Point m. |
| | | 008 | bareoptic / 24° | White reference | |
| | | 009 - 013 | bareoptic / 24° | Profile across a thermokarst mound with grass and *Salix* sp. | Profile m. |
| | | 014 / 015 | bareoptic / 24° | Grass, dry | Point m. |
| | | 016 / 017 | bareoptic / 24° | Sediment spot | Point m. |
| | | 018 - 024 | bareoptic / 24° | Profile between thermokarst mounds with more grass | Profile m. |
| | **Bkh05d surface of the 3rd terrace** | 026 - 042 | bareoptic / 24° | Profile across the surface 3rd terrace with various vegetation units, *Salix* sp., moss spots, grass spots, start: 126° 15' 35.53" E 72° 19' 14.95" N, end: 126° 15' 40.03" E 72° 19' 14.91" N | Profile m. |
| | | 043 / 044 | bareoptic / 24° | *Salix sp., 3rd terrace* | Point m. |
| | | 045 / 046 | bareoptic / 24° | Moss spot, green, 3rd terrace | Point m. |
| | | 047 / 048 | bareoptic / 24° | Grass spot, 3rd terrace | Point m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basy-Sise / T008 / 18.08.2005 / ca. 10:30 / 123° 48' 18.90" E 72° 57' 51.40" N** | Sand area, ca. 8m above the Channel (Camp site), Weather: low windy, low cloudy, sunny | | | Surface conditions: sandy, dry, flat relief, vegetation: sparse covered (about 60% cover range) moss, lichens, sporadic grass up to 20cm high and herbs low vegetation, about 5 cm high | |
| | | 000 | bareoptic / 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic / 24° | Sandy soil, dry grass, *Cassiope tetragona*, 60% cover range | Point m. |
| | | 003 / 004 | bareoptic / 24° | Small wall, dry, dominantly moss (green), diverse lichens (reindeer moss), Dryas sp., relative dense covered | Point m. |
| | | 005 / 006 | bareoptic / 24° | Sandy, plant cover ca.80%, moss (green), herbs, 3-4cm high | Point m. |
| | | 007 / 008 | bareoptic / 24° | Reference area (ca 1x1m), sandy, dry, plant cover 50%, less moss, *Dryas* sp., *Salix* sp., *Cassiope tetragona*, *Vaccinium* sp., sporadic grass, plant height about 2cm, 123° 48' 18.14" E 72° 57' 52.66" N | Point m. |
| | | 009 / 010 | bareoptic / 24° | Sand with wind ripples, light-yellowish, fine to middle sand, fluvial accumulated, aeolian reworked, without vegetation | Point m. |
| | | 011 - 020 | bareoptic / 24° | Profile ca.50m from W - E across a sand area, vegetation dry, similar to reference area sparse covered, less moss, sporadic dry cotton grass, | Profile m. |
| | | 021 - 028 | bareoptic / 24° | Profile from E - W across the same surface | Profile m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basyn-Sise / T009 / 18.08.2005 / ca. 11:30 / 123° 48' 26.39" E 72° 57' 46.64" N** | Higher flood plain level (episodic flooded area) SE below the camp, about 1 -2 m above the channel level, Weather: sunny, sporadic cirrostratus | | | Flat relief, vegetation 30-40cm high, sedge and Salix sp. at moss, mostly tussocks, in-between stagnant, brown water, active layer in tussocks about 40cm, in-between ca. 30cm | |
| | | 000 | bareoptic / 24° | White reference | |
| | | 001 / 002 | bareoptic / 24° | Grass tussock (Cyperacaea) at moss about 30cm high | Point m. |
| | | 003 / 004 | bareoptic / 24° | Dominantly Salix sp. at moss pillows and stagnant water | Point m. |
| | | 005 / 006 | bareoptic / 24° | Grass tussock (Cyperacaea) but more green and flat | Point m. |
| | | 007 / 008 | bareoptic / 24° | stagnant water, about 5cm deep, brown | Point m. |
| | | 009 - 019 | bareoptic / 24° | Profile about from NW to SE about 60m, Measuring (m.) points every 4m, start: see above, end: 123° 48' 27.25" E 72° 57' 45.60" N | Profile m. |
| | | 020 - 028 | bareoptic / 24° | Profile from S to N across the similar surface | Profile m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basyn-Sise / T010 / 18.08.2005 / ca.12:15 / 123° 48' 14.54" E 72° 57' 56.26" N** | Polygon tundra, ca. 1 - 2 m lower surface level in western direction near the camp site, weather: sunny, clear | | | Relief to the lake slightly sloping, orthogonal low-centre polygons, 12 - 18m in diameter, centres with stagnant water, dryer walls, in average 50cm high vegetation at the walls: moss, sedge, grass, *Betula* sp., *Salix* sp., *Dryas* sp., diverse lichens, some herbs, active layer between 30 and 40cm, polygon centers: stagnant water, about 10cm deep, vegetation tussocks with Sphagnum sp. and sedge (about 30cm high), sporadic cotton grass, active layer in average 45cm | |
| | | 000 | bareoptic / 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic / 24° | Polygon wall | Point m. |
| | | 003 / 004 | bareoptic / 24° | Moss spot (Sphagnum sp.) green, wet | Point m. |
| | | 005 / 006 | bareoptic / 24° | Polygon centre, stagnant water across moss, sedge in small tussocks | Point m. |
| | | 007 / 008 | bareoptic / 24° | Cotton grass, relative dense covered, in stagnant water | Point m. |
| | | 009 / 010 | bareoptic / 24° | Iron precipitation at the rims of a pond wetter to moister soil | Point m. |
| | | 011 / 012 | bareoptic / 24° | Pond with stagnant water, grass | Point m. |
| | | 013 - 024 | bareoptic / 24° | Profile across several polygons ca. from NE to SW | Profile m. |
| | | 025 - 034 | bareoptic / 24° | Profile from SW to NE across the same surface | Profile m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Ebe-Basyn-Sise / T011a / 18.08.2005 / ca. 14:00 /** 123° 47' 29.47" E 72° 58' 9.25" N | Flood plain in front of the alass at Ebe-Basyn-Sise, Weather: sunny, clear | Relief: slightly sloping from the alas to the channel, soil: relative wet, partly stagnant water, drift wood, vegetation dominantly *Salix* sp. and sedge at moss pillows, sporadic cotton grass areas | | | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic/ 24° | Poacea and sedge at moss pillows about 20cm high, sporadic equisetum | Point m. |
| | | 003 / 004 | bareoptic/ 24° | *Salix sp.*-shrub about 30cm high, underneath grass and moss | Point m. |
| | | 005 / 006 | bareoptic/ 24° | Driftwood about 2m long, 30 cm in diameter, dry, bleached | Point m. |
| | | 007 - 020 | bareoptic/ 24° | Profile across the flood plain | Profile m. |
| **Ebe-Basy-Sise / T011b / 18.08.2005 / 123° 47' 84" E 72° 58' 86" N** | Flood plain, location about 200m north of T011a, 20m from the channel shore | Dominantly reddish grass (*Arctophylla* sp.), about 30 - 50cm high, in-between sporadic dry cotton grass, vegetation pressed down by wind, cover range 80 - 90%, very wet soil between the vegetation, sometimes 2 - 3cm stagnant water, active layer between 70 and 80 cm deep | | | |
| | | 021 / 022 | bareoptic/ 24° | | Point m. |
| **Island Ebe-Basyn-Sise / T012 18.08.2005 / 123° 46' 41.09" E 72° 58' 6.26" N** | Alas depression, location ca. 150 m from the elongated lake towards the channel | Relief, relative flat area, low-centre polygons, soil relative wet, medium drained, vegetation: moss and sedge, sporadic cotton grass, at dryer places more Salix sp., 20-30cm high, sporadic driftwood trunks, active layer: walls about 30 cm, in wetter places 35-40 cm | | | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic/ 24° | Wet depression (polygon centre?), moss and sedge, 20-30 cm high | Point m. |
| | | 003/004 | bareoptic/ 24° | Wall, soil dry, better drained, *Salix* sp., dryer moss, sedge and grass | Point m. |
| | | 005 - 015 | bareoptic/ 24° | Profile across wet polygon centres and dryer polygon walls, ca. from NW to SE | Profile m. |

Appendix 4-1: Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Turakh-Sise / T019 / 25.08.2005 / 13:15 123° 50' 6.31" E 72° 58' 53rd 89" N** | Alas depression,location at the southern lake, southern lake shore, weather: varying clouded, a lot of Cirrus cloudes, Measuring (m.) limited only by open sky | Vegetation, more or less unique, *Salix* sp. between partly dry grass at moss pillows, sporadic cotton grass, vegetation cover almost 100%, height about 30cm, active layer in average 30cm deep | | | |
| | | 000 | bareoptic / 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic / 24° | *Salix sp.* between grass and moss pillows vegetation relative dry | Point m. |
| | | 003 / 004 | bareoptic / 24° | 2 cm deep, stagnant, brown water with grass (greener), about 30 cm high | Point m. |
| | | 005 / 006 | bareoptic / 24° | more *Salix* sp. between dryer grass | Point m., cloudy at 006 |
| | | 007 / 008 | bareoptic / 24° | error | Point m., clouded |
| | | 009 - 019 | bareoptic / 24° | Profile at the lake shore, 014 and 017 - 019 dominantly stagnant water | Profile m. |
| **Island Ebe-Basyn-Sise/ T048 / 31.08.2005 / 11:40 / 123° 45' 19.56" E 72° 58' 35.17" N** | Sand bluff at the channel location western edge at the end of the alas depression, weather: sunny, clear, sporadice Cirrus cloudes, light windy, about 10°C | Vegetation, very sparse covered, about 20% cover, autumnal dwarf shrub beneath dry grass and moss, plant height max. 20 cm, active layer depth about 1.05 m | | | |
| | | 000 | bareoptic / 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic / 24° | Sand, dry with autumnal *Salix* sp. | Point m. |
| | | 003 - 007 | bareoptic / 24° | Profile at the bluff, about 25m towards the shore (N) | Profile m. |

Appendix 4-1: Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basyn-Sise / T049 / 31.08.2005 / 11:52 / 123° 45' 8.90" E 72° 58' 33rd 48" N** | **T049a western wall of the alas , upper slope** | Hummock-surface | | | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic/ 24° | Area between hummocks with yellowish lichens and reindeer moss, *Cassiope tetragona* (dry), sporadic *Dryas* sp. | Point m. |
| | | 003/004 | bareoptic/ 24° | Hummock with *Dryas* sp., *Cassiope tetragona,* reindeer moss, dry moss, scab lichens and various Ericacaea | Point m. |
| | | 005 - 020 | bareoptic/ 24° | Profile across the alass wall (upper slope), start see above end: 123° 45' 2.67" E 72° 58' 31.39" N | Profile m. |
| | | 021 / 022 | bareoptic/ 24° | Dry, grayish moss and yellow lichen | Point m. |
| | **T049b** | 023 - 049 | bareoptic/ 24° | Profile from transition area to the tundra across alas rim to the alas depression, start: 123° 44' 58.32" E 72° 58' 34.09" N end: 123° 45' 10.23" E 72° 58' 30.38" N | Profile m. |
| | | 050 / 051 | bareoptic/ 24° | *Cassiope tetragona* | Point m. |
| **Island Ebe-Basyn-Sise / T050 / 31.08.2005 / 12:26 / 123° 45' 6.67" E 72° 58' 35.21" N** | *low-centre polygon, transitions area between alas rim to the tundra, Weather, (see T048)* | Polygon about 10 - 12 m in diameter, polygon centre about 6 m, about 50 - 80 cm high polygon walls, vegetation: polygon centres, 10 cm deep stagnant water with dominantly sedge (30 - 40 cm high), partly sere, about 60% cover, polygon walls dry, similar to alass rims with lichens, moss, less grass | | | |
| | | 000 / 001 | bareoptic/ 24° | Polygon centre | Point m. |
| | | 002 / 003 | bareoptic/ 24° | Polygon wall | Point m. |
| | | 004 - 022 | bareoptic/ 24° | Profile across several polygons, start: see above end: 123° 44' 55.37" E 72° 58' 34.81" N | Profile m. |
| | | 023 / 024 | bareoptic/ 24° | Water, small pond, about 50cm deep, with thin ice cover | Point m. |
| | | 025/026 | bareoptic/ 24° | Pond shore, moss spot (*Sphagnum* sp., green-yellowish, very wet) and grass | Point m. |
| | | 027/028 | bareoptic/ 24° | Pond shore, moss spot (*Sphagnum* sp., green-yellowish, very wet) with sporadic grass blades | Point m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basyn-Sise / T051 / 31.08.2005 / 13:28 / 123° 45' 0.55" E 72° 58' 28.04" N** | Alas depression, several surface structures, constant weather conditions | | | Surface conditions very wet, with stagnant water, unclear polygon pattern elongated polygon walls parallel to the alas rim, and to the lake shore, without clear cross links and between depressions of polygon centres, very wet, bad drained | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | **T051a** | 001 / 002 | bareoptic/ 24° | Western slope foot of the alas rim, characteristic for an about 20 m wide sedge zone about 20 - 30cm high, on *Sphagnum* sp.-pillows partly dry (50:50) | Point m. |
| | | 003 - 023 | bareoptic/ 24° | Profile across the NW-part of the alas depression towards a silted-up lake (boggy) lake, from the slope base of the alas rim across alternation of elongated polygon walls (slope parallel) and depressions with stagnant water, start: see above end: 123° 45' 10.49" E 72° 58' 25.88" N | Profile m. |
| | | 024 / 025 | bareoptic/ 24° | Spot with green-yellowish moss, sporadic grass and finger lichens | Point m. |
| | | 026 / 027 | bareoptic/ 24° | Micro pingo in the silted-up, boggy lake, with dominantly dry grass, underneath moss pillows, sporadic cotton grass | Point m. |
| | **T051b** | 028 / 029 | bareoptic/ 24° | Silted-up, boggy part of an alas lake with greenish *Arctophylla* sp. and cotton grass, water depth about 5 - 10cm above moss pillows, penetration depth into moss min. 30 m to the permafrost level | Point m. |
| | | 030 / 031 | bareoptic/ 24° | Similar surface conditions like 028 / 029, but more Sphagnum sp. at the water surface and reddish *Arctophylla* sp. | Point m. |
| | | 032 / 033 | bareoptic/ 24° | Similar surface conditions dominantly reddish *Arctophylla* sp. and green Sphagnum sp. at the water surface | Point m. |
| | | 034 / 035 | bareoptic/ 24° | Smaller reddish *Arctophylla* sp. and green-brownish *Sphagnum* sp. below water surface | Point m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Ebe-Basyn-Sise / T052 / 31.08.2005 / 14:13 / 123° 45' 34.32" E 72° 58' 24.80" N** | Drift wood zone at the northern bluff, which border the alas to the channel | | | White reference | |
| | | 001 - 010 | bareoptic/ 24° | Profile across the drift wood zone, start: see above, end: 123° 45' 38.42" E 72° 58' 23rd 22" N | Profile m. |
| | | 011 / 012 / 013 / 014 | bareoptic/ 24° | Drift wood trunks | Point m. |
| **Island Ebe-Basyn-Sise / T053 / 31.08.2005 / 15:52 / 123° 48' 30.02" E 72° 57' 46.82" N** | higher flood plain level(episodically flooded area), (see T009) | | | Renewed point m. and profiles at the lower flood plain level, vegetation: see T009, but now autumnally colored and dryer grass, 20 - 30 cm high, active layer between 35 and 40 cm deep | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic/ 24° | Autumnal *Salix* sp. and dryer grass at moss pillows | Point m. |
| | | 003 - 021 | bareoptic/ 24° | Profile across the upper flood plain level to the lower level, transition ca. at point 011, small and flat bluff, about 1,50 m high, start: see above end: 123° 48' 41.76" E 72° 57' 44.45" N | Profile m. |
| | | 022 / 023 | bareoptic/ 24° | Lowest flood plain level 30-40 cm high, autumnal Salix sp.-shrubs, underneath partly dry grass about 20 cm high, active layer in average 70cm deep | Point m. |
| | | 024 / 025 | bareoptic/ 24° | Grass spot about 2 m in diameter, without Salix sp., grass about 10 cm high, dry | Point m. |
| | | | | | |
| | | 026 | bareoptic/ 24° | White reference | Point m. |
| | | 027 / 028 | bareoptic/ 24° | Reference area (see T008), vegetation: autumnal, silty surface because of frequent precipitation | Point m. |

**Appendix 4-1:** Continuation

| Position /date / time / coordinates | Location / Weather conditions | Record No. | Optic | Characteristics: Surface / Vegetation | Measuring (m.) process / Remark |
|---|---|---|---|---|---|
| **Island Turakh-Sise / T054 / 31.08.2005 17:41 / 123° 48' 04" E 72° 58' 29.95" N** | at the slip-off slope of a meandering brook valley, small valley from the channel to the 1st alas lake | Vegetation, dominantly grass and sedge to 40 cm high at dry moss pillows smaller areas with autumnal *Salix* sp., Changing moisture conditions from the brook (wet) to the slope (relative dry) | | | |
| | | 000 | bareoptic/ 24° | White reference | Point m. |
| | | 001 / 002 | bareoptic/ 24° | Green grass and sedge, about 10-15 cm high, with dryer places, 3 m distance to the brook shore, active layer 25 to 40 cm deep | Point m. |
| | | 003 / 004 | bareoptic/ 24° | Brook shore, reddish *Arctophylla* sp. directly at the water surface | Point m. |
| | | 005 / 006 | bareoptic/ 24° | *Arctophylla sp.* less frequent below and above the water level | Point m. |
| | | 007 / 008 | bareoptic/ 24° | Brook, floating water, about 25cm deep, brown brook bottom | Point m. |
| | | 009 - 019 | bareoptic/ 24° | Profile across slip-off slope to the valley slope crossing several surfaces, start: see above, end. 123° 48' 37.65" E 72° 58' 31.64" N | Profile m. |
| | | 020 / 021 | bareoptic/ 24° | Polygon tundra at the upper slope of the valley slope, transition to the alas depression, only polygon centre measured | Point m. |

**Appendix 4-2:** List of sediment samples (see chapter 4.5)

| No | sample | height [m asl] | height [m] | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| Kurungunakh Island, drained thermokarst lake, old lake bottom; 72.3219 °N, 126.4786 °E, 13.08.2005 | | | | | | | | | |
| 1 | Bkh-05-3 | | | 0.6 | lake deposits, organic-rich, silt | dark grey | unfrozen | | |
| 2 | Bkh-05-1 | | | 0.1 | | dark grey | unfrozen | | |
| 3 | Bkh-05-2 | | | 0.34 | lake deposit, peat inclusion | dark brown | unfrozen | | |
| Ebe-1: fox cave on Ebe Sise Island, 72,9430 °N, 123,6314 °E; 19.08.2005 | | | | | | | | | |
| 4 | Ebe-1-1 | | | 0.2 | fine sand (fox cave) | light-brown | unfrozen | | |
| Ebe-2: dig on Ebe Sise Island, hill slope near thermokarst lake, 72,9279 °N, 123,6079 °E, 19.08.2005 | | | | | | | | | |
| 5 | Ebe-2-S-1 | | | 0.94 | fine sand | grey | massive | 16 | 19.1 |
| 6 | Ebe-2-S-2 | | | 0.85 | | | | 15.8 | 18.8 |
| 7 | Ebe-2-S-3 | | | 0.75 | fine sand, banded/ bedded, buried soil? | grey | unfrozen | | |
| 8 | Ebe-2-S-4 | | | 0.6 | silty fine sand, modern roots, not bedded | greyish-brown | unfrozen | | |
| 9 | Ebe-2-S-5 | | | 0.4 | soil, organic rich, silty fine sand, roots | brownish | unfrozen | | |
| 10 | Ebe-2-S-6 | | | 0.2 | uppermost soil horizon, | brown | unfrozen | | |
| Ebe-3: dig on Ebe Sise Island, hill slope near thermokarst lake, 72,9267 °N, 123,6033 °E, 19.08.2005 | | | | | | | | | |
| 11 | Ebe-3-S-1 | | | 0.6 | fine-sand, Fe oxid impregnations, bands, rings | brownish-grey | massive, small ice veins | 20.2 | 25.3 |
| 12 | Ebe-3-S-2 | | | 0.5 | | | | 23.6 | 31 |
| 13 | Ebe-3-S-3 | | | 0.4 | | | | 19.7 | 24.5 |
| Ebe-4: exposure below the camp site, 72,9653°N, 123,8071°E, 22.08.2005 | | | | | | | | | |
| 14 | Ebe-4-1 | 6.411 | | 0.35 | sand, modern roots, banded | grey | unfrozen | | |
| 15 | Ebe-4-2 | 6.011 | | 0.75 | fine-sand, spotty, roots, dark denser layers | grey, dark grey, brownish | unfrozen | | |
| 16 | Ebe-4-3 | 5.761 | | 1 | fine-sand, middle-sand, roots | | unfrozen | | |
| 17 | Ebe-4-4 | 5.261 | | 1.5 | silty fine-sand, alterations, banded 2 cm, organic | grey, dark grey | | | |
| 18 | Ebe-4-5 | 5.011 | | 1.75 | fine-sand, middle-sand, roots | yellowish-grey | unfrozen | | |
| 19 | Ebe-4-6 | 4.561 | | 2.2 | fine-san, middle-sand, roots | grey, brownish | massive | 17,6 | 21.4 |
| 20 | Ebe-4-7 | 4.311 | | 2.45 | fine-sand, peat inclusion | grey, brown | massive | | |
| 21 | Ebe-4-8 | 4.161 | | 2.6 | peat inclusion, fine-sand, frost crack with sand filling | grey, yellowish | massive | 22.6 | 29.3 |
| 22 | Ebe-4-9 | 3.911 | | 2.85 | peat, cryoturbation fine sand | brown | | 50.4 | 101.8 |
| 23 | Ebe-4-10 | 3.761 | | 3 | | brown, grey | massive | 26.1 | 35.4 |
| 24 | Ebe-4-11 | 3.611 | | 3.15 | | brown | polozatik | | |
| 25 | Ebe-4-12 | 3.361 | | 3.4 | peat clast, fine-sandy matrix | brown, yellowish-grey | | | |
| 26 | Ebe-4-13 | 3.111 | | 3.65 | fine-sand, weakly bedded, plant detritus | greyish-brown, yellowish | massive | 19.5 | 24.1 |
| 27 | Ebe-4-14 | 2.761 | | 4 | | | | | |
| 28 | Ebe-4-15 | 2.561 | | 4.2 | fine-sand, spotty | lighter | massive | 16.7 | 20 |
| 29 | Ebe-4-16 | 2.211 | | 4.55 | fine-sand | yellowish-grey | massive | 17,6 | 21.4 |
| 30 | Ebe-4-17 | 1.911 | | 4.85 | | | | 19.3 | 23.9 |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | height [m] | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| Ebe-5: exposure south on Ebe Sise Island, 72.92 °N, 123.68 °E, 31.08.2005, V. Kunitsky, T. Kuznetsova | | | | | | | | | |
| 31 | Ebe-5-1 | | 3.2 | | middle to fine sand, ripple bedded, | grey | massive | | |
| 32 | Ebe-5-2 | | 3.6 | | middle to fine sand, bedded, | grey | massive | | |
| 33 | Ebe-5-3 | | 3.9 | | middle to fine sand, bedded, | grey | unfrozen | | |
| 34 | Ebe-5-4 | | 4.05 | | middle to fine sand, fine laminated, | grey | unfrozen | | |
| 35 | Ebe-5-5 | | 4.75 | | | | | | |
| 36 | Ebe-5-6 | | 5 | | | | | | |
| Exposure near the drill site on Turakh Island, 72.9740 °N, 123.7986 °E, 18./20.08.2005 | | | | | | | | | |
| 42 | Tur-1-S-14 | 5.18 | | 0.2 | fine sand, dunes | light-grey | unfrozen | | |
| 41 | Tur-1-S-13 | 4.78 | | 0.6 | fine sand, dune, bedded | light-grey | unfrozen | | |
| 40 | Tur-1-S-12 | 4.58 | | 0.8 | fine sand, banded, buried soil | grey to dark-brown | unfrozen | | |
| 39 | Tur-1-S-11 | 4.49 | | 0.9 | fine sand, buried soil, banded | grey to dark-brown | unfrozen | | |
| 38 | Tur-1-S-10 | 4.38 | | 1 | driftwood | brown | unfrozen | | |
| 52 | Tur-1-S-9 | 4.38 | | 1.0 | alluvial peat, dense, bedded | dark-brown | unfrozen | | |
| 51 | Tur-1-S-8 | 4.28 | | 1.1 | | | | | |
| | Tur-OSL-4 (Tur-1) | 2.88 | | 2.5 | fine-sand, middle sand, peat inclusions | | | | |
| 49 | Tur-1-S-6 | 4.08 | | 1.3 | sand, Fe-oxid impregnations, banded | greyish/brown | massive, ice veins | 26.7 | 36.3 |
| 50 | Tur-1-S-7 | 4.18 | | 2.7 | alluvial peat, dense, bedded | dark-brown | unfrozen | | |
| 48 | Tur-1-S-5 | 3.58 | | 2.9 | sand, fine grained | yellowish-grey | massive | 9 | 9.9 |
| 47 | Tur-1-S-4 | 3.38 | | 3 | sand, single small peat inclusions | grey | ice schliers, diagonal | 29.1 | 41 |
| 46 | Tur-1-S-3 | 2.88 | | 2.5 | peat inclusion, near the long ice wedge | dark-brown | massive | 43.4 | 76.8 |
| | Tur-OSL-3 (Tur-1) | 2.88 | | 2.5 | fine-sand, middle-sand, organic, spotty | | | | |
| 45 | Tur-1-S-2 | 2.58 | | 2.8 | sand | yellowish | massive | 24.5 | 32.5 |
| 37 | Tur-1-S-1 | 1.38 | | 4.0 | sand, without structures | yellowish-grey | massive | 17 | 20.5 |
| 43 | Tur-1-S-15 | 1.18 | | 4.2 | fine sand, middle sand alternation, cross bedded | greyish-brown | massive, small ice veins | | |
| | Tur-OSL-2 (Tur-1) | 0.88 | | 4.5 | fine-sand, middle-sand, weakly bedded | | | | |
| 44 | Tur-1-S-16 | 0.88 | | 4.5 | fine sand, middle sand, alternation, cross bedded | greyish-brown | massive, small, thin ice veins | | |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | Sample interval | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| Tur-2: Drill core on Turakh Island, 72,97401°N, 12379858°E, 20., 23., 24., 26. 27.29. 8. 2005 | | | | | | | | | |
| 53 | Tur-2-1 | 0.477 | 1-1.1 | 1.04 | fine-sand, like in the outcrop Tur-1 | grey | massive | | |
| 54 | Tur-2-2 | 0.317 | 1.1-1.25 | 1.2 | fine sand | grey | ice wedge, 1.5 cm broad, | | |
| 55 | Tur-2-3 | 0.227 | 1.25-1.35 | 1.29 | fine-sand | grey | | | |
| 56 | Tur-2-4 | 0.147 | 1.35-1.40 | 1.37 | fine sand | grey | | | |
| 57 | Tur-2-5 | 0.067 | 1.40-1.50. | 1.45 | fine-sand | grey | | | |
| 58 | Tur-2-6 | | 1.50-1.53 | 1.515 | ice wedge | | | | |
| 59 | Tur-2-7 | -0.03 | 1.53-1.60 | 1.55 | fine-sand | grey | | | |
| 60 | Tur-2-8 | -0.12 | 1.60-1.70 | 1.64 | fine-sand | grey | massive | 16.2 | 19.4 |
| 61 | Tur-2-9 | -0.35 | 1.83-1.90 | 1.87 | fine-sand | grey | massive | | |
| 62 | Tur-2-10 | -0.43 | 1.90-2.00 | 1.95 | fine-sand, | grey | massive | | |
| 63 | Tur-2-11 | -0.52 | 2.05-2.10. | 2.04 | fine-sand | greyish-brown | massive | 13.2 | 15.1 |
| 64 | Tur-2-12 | -0.63 | 2.1--2.20. | 2.15 | | | | | |
| 65 | Tur-2-13 | -0.73 | 2.20-2.30 | 2.25 | | | | | |
| 66 | Tur-2-14 | -0.82 | 2.30-2.40. | 2.34 | | | | | |
| 67 | Tur-2-15 | -0.91 | 2.40-2.55 | 2.43 | bedded, thin silt interbeds, fine-sand | greyish-brown | massive | 18.6 | 22.9 |
| 68 | Tur-2-16 | -1.04 | 2.40-2.55. | 2.56 | | | | | |
| 69 | Tur-2-17 | -1.09 | 2.60-2.75. | 2.61 | | | | | |
| 70 | Tur-2-18 | -1.27 | 2.75-2.85 | 2.79 | | | | | |
| 71 | Tur-2-19 | -1.88 | 3.35-3.45 | 3.4 | fine-sand | greyish-brown | massive | | |
| 72 | Tur-2-20 | -2.02 | 3.50-3.60. | 3.54 | fine-sand | greyish | massive | 19.1 | 23.6 |
| | Tur-OSL-1-gamma | -2.09 | 3.60-3.65. | 3.61 | fine sand, middle-sand | | | | |
| | Tur-OSL-1 (Tur-2) | -2.18 | 3.65-3.77, | 3.7 | | | | | |
| 73 | Tur-2-21 | -2.3 | 3.80-3.85. | 3.82 | | greyish-brown | massive | | |
| 74 | Tur-2-22 | -2.38 | 3.85-3.95 | 3.9 | middle to coarse-sand, interbeds, 5-10 cm layers | light grey, yellowish | massive | 18.4 | 22.6 |
| 75 | Tur-2-23 | -2.49 | 3.95-4.09 | 4.01 | fine-sand | grey | massive | | |
| 76 | Tur-2-24 | -2.59 | 4.09-4.12. | 4.11 | middle-sand, bedded | light-grey, yellowish | massive | | |
| 77 | Tur-2-25 | -2.63 | 4.12-4.18. | 4.15 | fine-sand, bedded, 1mm organic layers | brownish-grey | massive | 18.8 | 23.2 |
| 78 | Tur-2-26 | -2.69 | 4.18-4.25 | 4.21 | middle sand | yellowish-brown | massive | | |
| 79 | Tur-2-27 | -2.8 | 4.25-4.37 | 4.32 | middle-sand | | | 14.9 | 17.4 |
| 80 | Tur-2-28 | -2.99 | 4.50-4.55. | 4.51 | middle-sand | | | | |
| 81 | Tur-2-29 | -3.17 | 4.64-4.74. | 4.69 | fine-sand | greyish-brown | massive | 18.4 | 22.6 |
| 82 | Tur-2-30 | -3.36 | 4.85-4.92. | 4.88 | fine-sand | | massive | | |
| | Tur-OSL-5 | -3.48 | 4.95-5.07, | 5 | middle to fine-sand | | | | |
| 83 | Tur-2-31 | -3.63 | 5.13-5.19. | 5.15 | middle-sand | brown | massive | | |
| 84 | Tur-2-32 | -3.69 | 5.19-5.25. | 5.21 | middle-sand | brown | massive | 17,4 | 21 |
| 85 | Tur-2-33 | -3.82 | 5.30-5.35 | 5.34 | interbedding, middle to fine-sand, 1 cm, black grains, organic remains | brown to greyish-brown | massive | | |
| 86 | Tur-2-34 | -3.88 | 5.37-5.45. | 5.4 | | | | 19.4 | 24 |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | Sample interval | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| 87 | Tur-2-35 | -4.05 | 5.55-5.60. | 5.57 | middle to coarse-sand | brown | massive | | |
| 88 | Tur-2-36 | -4.13 | 5.,6-5.7, | 5.65 | graded bedding, fine to middle-sand, small laminaes | brown to grey | massive | 19.2 | 23.7 |
| 89 | Tur-2-37 | -4.21 | 5.70-5.78. | 5.73 | | | massive | | |
| 90 | Tur-2-38 | -4.28 | 5.78-5.83. | 5.8 | fine-sand | grey | ice rich | | |
| 91 | Tur-2-39 | -4.34 | 5.83-5.88 | 5.86 | ice | | ice wedge, vertical gas bubbles | 42.7 | 74.6 |
| 92 | Tur-2-40 | -4.38 | 5.88-5.95. | 5.9 | fine sand to middle-sand | greyish-brown | massive | | |
| 93 | Tur-2-41 | -4.48 | 5.95-6.02. | 6 | middle sand, oxidation spots | brown | massive | | |
| 94 | Tur-2-42 | -4.55 | 6.02-6.10. | 6.07 | middle sand, ox. spots, -bands, pedogene, organic | brown | massive | 16.4 | 197 |
| 95 | Tur-2-43 | -4.63 | 6.10-6.20. | 6.15 | | | massive | | |
| 96 | Tur-2-44 | -4.73 | 6.20-6.30. | 6.25 | | | | | |
| 97 | Tur-2-45 | -4.8 | 6.36-6.43 | 6.32 | | | massive | | |
| 98 | Tur-2-46 | -4.88 | 6.36-6.43 | 6.4 | | | massive | 22.2 | 28.5 |
| | Tur-OSL-6 | -4.98 | 6.43-6.58 | 6.5 | | | | | |
| 99 | Tur-2-47 | -5.09 | 6.58-6.66. | 6.61 | fine sand, organic inclusions 2 mm, ox. Spots | grey, brown | massive | | |
| 100 | Tur-2-48 | -5.17 | 6.66-6.73 | 7,69 | | | massive | | |
| 101 | Tur-2-49 | -5.26 | 6.73-6.79. | 6.78 | | | massive | 25.3 | 33.9 |
| 102 | Tur-2-50 | -5.32 | 6.83-6.87 | 6.84 | | | massive | | |
| 103 | Tur-2-51 | -5.38 | 6.87-6.92 | 6.9 | | | | | |
| 104 | Tur-2-52 | -5.42 | 6.92-6.98 | 6.94 | fine sand, ox. spots | grey, orange-brown | massive | | |
| 105 | Tur-2-53 | -5.49 | 6.98-7,06 | 7,01 | fine sand, organic, ox. Spots | | massive | | |
| 106 | Tur-2-54 | -5.59 | 7,06-7,13 | 7,11 | fine sand, grey, organic, twigs, ox. Spots | grey, brown | | 19.7 | 24.5 |
| 107 | Tur-2-55 | -5.73 | 7.19-7.30 | 7,25 | fine to middle sand, ox. spots, organic | grey, orange-brown | massive | | |
| 108 | Tur-2-56 | -5.82 | 7,30-7,38. | 7,34 | fine to middle sand, organic | grey, brown | massive | | |
| 109 | Tur-2-57 | -5.88 | 7,38-7,44 | 7,4 | middle sand, organic, ox. spots | grey, brown, dark-brown | massive | | |
| 110 | Tur-2-58 | -5.98 | 7,44-7,53 | 7,5 | middle to fine-sand, plant inclusions 1-2 mm, ox. spots; | grey, brown | massive | 19.6 | 24.4 |
| 111 | Tur-2-59 | -6.09 | 7,57-7,65. | 7,61 | middle to fine-sand, plant inclusions | grey, brown | | | |
| 112 | Tur-2-60 | -6.17 | 7,65-7,71. | 7,69 | fine to middle sand, weakly bedded, ox. spots; | grey, brown | | 18.9 | 23.3 |
| 113 | Tur-2-61 | -6.26 | 7,75-7,82 | 7,78 | fine to middle-sand, weakly bedded, ox. spots; | grey, brown | | | |
| 114 | Tur-2-62 | -6.34 | 7,82-7,90. | 7,86 | fine to middle-sand, weakly bedded, ox. spots; | | | | |
| 115 | Tur-2-63 | -6.42 | 7,90-7,98 | 7,94 | fine sand, silt, organic, ox. spots, weakly bedded | grey, orange-brown | massive | 22.8 | 29.5 |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | Sample interval | depth [m] | lithology | colour | cryo-structure | Ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| 116 | Tur-2-64 | -6.54 | 8.01-8.11. | 8.06 | fine sand, silt, organic-rich, ox. spots | grey, light-brown, orange-brown | | | |
| 117 | Tur-2-65 | -6.59 | 8.11-8.14. | 8.11 | fine to middle-sand, silt, organic-rich, ox.spots | grey, light-brown, orange-brown | massive | | |
| 118 | Tur-2-66 | -6.63 | 8.14-8.19. | 8.15 | fine sand, organic, ox.spots | grey, orange-brown | massive | | |
| 119 | Tur-2-67 | -6.7 | 8.19-8.24. | 8.22 | middle sand, ox.spots, fine-sand, bedded | grey, brownish | massive | 22.2 | 28.6 |
| 120 | Tur-2-68 | -6.78 | 8.26-8.35. | 8.3 | fine sand, weakly bedded | grey | | | |
| 121 | Tur-2-69 | -6.86 | 8.33-8.43. | 8.38 | middle to fine-sand, organic-rich, plant remains | | | | |
| 122 | Tur-2-70 | -6.94 | 8.43-8.47, | 8.46 | fine sand | grey | | | |
| 123 | Tur-2-71 | -6.98 | 8.47-8.53. | 8.5 | fine sand, middle-sand band | grey, brownish | small ice cristalls | | |
| 124 | Tur-2-72 | -7,08 | 8.56-8.65 | 8.6 | fine-sand, middle-sand, small ox.spots, weakly bedded, organic | grey | | | |
| 125 | Tur-2-73 | -7,15 | 8.65-8.69. | 8.67 | middle-sand | light-grey | | | |
| 126 | Tur-2-74 | -7,23 | 8.69-8.77 | 8.75 | fine sand, organic; 8.78-8.80 ice content | grey | | 21.2 | 26.9 |
| 127 | Tur-2-75 | -7,33 | 8.80-8.91. | 8.85 | fine to middle-sand, bedded, organic-rich | grey, brownish | | | |
| 128 | Tur-2-76 | -7,45 | 8.93-90.1 | 8.97 | fine sand, plant remains, twigs, roots; 9.01-9.02 ice content | grey, brownish | massive | 47.2 | 89.3 |
| 129 | Tur-2-77 | -7,55 | 9.02-9.13 | 9.07 | fine sand, organic rich layer, mica layer, bedded | grey | massive | | |
| 130 | Tur-2-78 | -7,62 | 9.13-9.21 | 9.14 | peaty, fine to, middle-sand, plant remains; 9.21-9.23 ice content | grey, brown, light-grey | massive | 23.0 | 29.8 |
| 131 | Tur-2-79 | -7,73 | 9.23-9.27, | 9.25 | middle-sand, bedded | light-grey | | | |
| 132 | Tur-2-80 | -7,78 | 9.27-9.33 | 9.3 | fine to middle-sand, weakly bedded | grey, light-grey | | | |
| 133 | Tur-2-81 | -7,83 | 9.33-9.38. | 9.35 | fine-sand, organic-inclusion | grey | | | |
| 134 | Tur-2-82 | -7,87 | 9.38-9.43. | 9.39 | fine-sand | grey | | | |
| 135 | Tur-2-83 | -7,95 | 9.43-9.51. | 9.47 | bedded, organic-rich layers, fine-sand, mica-layers | grey, brownish | | | |
| 136 | Tur-2-84 | -8.03 | 9.51-9.58. | 9.55 | fine-sand, organic, mica | | | | |

**Appendix 4-2**: Continuation

| No | sample | height [m asl] | Sample interval | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| 137 | Tur-2-85 | -8.17 | 9.79-8.4. | 9.82 | middle to fine-sand, spotty, mica | grey, light-brown | | | |
| 138 | Tur-2-86 | -8.3 | 9.84-9.94. | 9.89 | middle to fine-sand, spotty, mica | grey | massive | | |
| 139 | Tur-2-87 | -8.37 | 9.94-10.6. | 10 | middle to, fine-sand, spotty, organic, mica | grey, brownish | | 26.4 | 35.8 |
| 140 | Tur-2-88 | -8.48 | 10.06-10.10. | 10.02 | middle sand, greyish-brown, mica | | | | |
| 142 | Tur-2-89 | -8.56 | 10.10-10.15. | 10.08 | middle sand, spotty | grey, light-brown | | | |
| 143 | Tur-2-90 | -8.65 | 10.15-10.20 | 10.17 | fine to middle-sand, mica, weakly bedded | grey | massive | | |
| 144 | Tur-2-91 | -8.71 | 10.20-10.26 | 10.23 | fine to middle-sand, organic, weakly bedded, mica | grey, brown | | | |
| 145 | Tur-2-92 | -8.78 | 10.26-10.34 | 10.3 | fine sand | grey | | 21.9 | 28 |
| 146 | Tur-2-93 | -8.85 | 10.34-10.41 | 10.37 | fine to middle-sand, spotty | grey | massive | | |
| 147 | Tur-2-94 | -8.93 | 10.41-10.50. | 10.45 | middle to fine-sand, weakly bedded, organic, spotty | | massive | | |
| 148 | Tur-2-95 | -9.01 | 10.50-10.57, | 10.53 | middle to fine-sand, organic, roots, twigs, weakly bedded | brown, grey | massive | 21.6 | 27.6 |
| 149 | Tur-2-96 | -9.08 | 10.57-10.62 | 10.6 | middle sand | brown | massive | | |
| 150 | Tur-2-97 | -9.14 | 10.62-10.70 | 10.66 | fine to middle-sand, spotty | grey, brownish | massive | | |
| 151 | Tur-2-98 | -9.21 | 10.70-10.77, | 10.73 | fine to middle-sand, spotty | grey, brownish | massive | 18.2 | 22.2 |
| 152 | Tur-2-99 | -9.3 | 10.77-10.86. | 10.82 | fine sand | ray | | | |
| 153 | Tur-2-100 | -9.36 | 10.86-10.90. | 10.88 | fine-sand | grey | | | |
| 154 | Tur-2-101 | -9.4 | 10.90-10.95. | 10.92 | fine-sand | gra | | | |
| 155 | Tur-2-102 | -9.48 | 10.95-11.05. | 11 | middle sand, spotty, black sulphide spots | brown, grey | | 17.6 | 21.4 |
| 156 | Tur-2-103 | -9.58 | 11.05-11.14. | 11.1 | | | | | |
| 157 | Tur-2-104 | -9.65 | 11.14-11.20. | 11.17 | fine-sand, middle-sand, | grey | | | |
| 158 | Tur-2-105 | -9.71 | 11.20-11.27, | 11.23 | fine-sand, middle-sand, weakly bedded, coal-like black inclusions | brownish-grey, black | | | |
| 159 | Tur-2-106 | -9.78 | 11.27-11.34. | 11.3 | | | | | |
| 160 | Tur-2-107 | -9.85 | 11.34-11.43. | 11.37 | | | | 17.6 | 21.4 |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | height [m]l | depth [m] | lithology | colour | cryo-structure | ice abs. | Ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| Kha-1: Khardang Island, lower sands, 72.9500 °N, 124.2080 °E, 26.08.2005 | | | | | | | | | |
| 161 | Kha-1-1 | | 0 | | fine to middle sand, cross-bedded, | grey | massive | | |
| 162 | Kha-1-2 | | 0.4 | | fine-sand, middle-sand, fine-bedded | grey | massive | 16.7 | 20.1 |
| 163 | Kha-1-3 | | 0.8 | | | | | | |
| 164 | Kha-1-4 | | 1 | | | | | | |
| 165 | Kha-1-5 | | 1.5 | | | | | 24.5 | 32.4 |
| 166 | Kha-1-6 | | 1.6 | | | | | | |
| | Kha-OSL-1 | | 2 | | fine-sand, middle-sand, fine-bedded | grey | massive | | |
| | Kha-OSL-2 | | 4 | | | grey | massive | | |
| Kha-2: Khardang Island, lower sand to Ice Complex, 72.9510 °N, 124.2220 °E, 27./30.08.2005 | | | | | | | | | |
| 167 | Kha-2-1 | | 3.1 | | peat inclusion | brown | massive | | |
| 168 | Kha-2-2 | | 4 | | fine sand, bedded | grey | massive | 20.5 | 25.7 |
| 169 | Kha-2-3 | | 4.2 | | peat inclusion | brown | massive | 35.3 | 54.7 |
| 170 | Kha-2-4 | | 4.4 | | fine sand, horizontal bedded | grey | massive | | |
| 171 | Kha-2-5 | | 4.6 | | peat, cryoturbation | brown | massive | | |
| 172 | Kha-2-6 | | 4.8 | | peat, moss | brown | massive | | |
| 173 | Kha-2-7 | | 5 | | peat, moss | brown | banded | 51.3 | 105.3 |
| 174 | Kha-2-8 | | 5.2 | | peat, moss | brown | massive | | |
| 175 | Kha-2-9 | | 5.4 | | peat, moss | brown | massive | | |
| 176 | Kha-2-10 | | 5.5 | | peat, moss | brown | massive | | |
| | Kha-U/Th-1 | | 5.4 | | peat, moss | brown | massive | | |
| | Kha-U/Th-2 | | 5.3 | | peat, moss | brown | massive | | |
| | Kha-U/Th-3 | | 5.2 | | peat, moss | brown | massive | | |
| | Kha-U/Th-4 | | 5.1 | | peat, moss | brown | massive | | |
| | Kha-U/Th-5 | | 5 | | peat, moss | brown | massive | | |
| 177 | Kha-2-11 | | 5.8 | | silty fine sand, cross bedded | brownish-grey | massive | | |
| 178 | Kha-2-12 | | 6.5 | | sand | grey, brown | massive | | |
| 179 | Kha-2-13 | | 6.6 | | peat | brown | massive | | |
| 180 | Kha-2-14 | | 6.9 | | fine sand, bedded | grey | massive | | |
| 181 | Kha-2-15 | | 7,3 | | fine sand, bedded | yellowish-grey | massive | | |
| 182 | Kha-2-16 | | 7,8 | | silty fine sand, aleurite | darkgrey, brown | banded | 30.5 | 43.9 |
| 183 | Kha-2-17 | | 8.2 | | sand, wavy bedded, cryoturbation, soil | grey, brown | banded | 20.8 | 26.3 |
| 184 | Kha-2-18 | | 8.6 | | silty fine sand, aleurite, | dark-grey, brown | banded | 27.4 | 37.7 |
| 185 | Kha-2-19 | | 7,7 | | fine sand, bedded | yellowish-grey | massive | | |
| 186 | Kha-2-20 | | 8.2 | | silty fine sand, (aleurite) plant remains | dark-grey, brown | lense-like reticulated | 49.1 | 96.3 |
| 187 | Kha-2-21 | | 8.7 | | | | | | |
| 188 | Kha-2-22 | | 9.2 | | | | | 32.3 | 47.6 |
| 189 | Kha-2-23 | | 9.8 | | peat inclusion | brown | massive | | |
| 190 | Kha-2-24 | | 10.1 | | peat inclusion | brown | massive | 18.6 | 22.9 |
| 191 | Kha-2-25 | | 10.5 | | silty fine sand, aleeurite, | darkgrey, brown | lense-like reticulated | | |

**Appendix 4-2:** Continuation

| No | sample | height [m asl] | height [m]l | depth [m] | lithology | colour | cryo-structure | ice abs. | ice grav. |
|---|---|---|---|---|---|---|---|---|---|
| 192 | Kha-2-26 | | 11 | | silty fine sand, alevrit, twigs | dark-grey, brown | lense-like reticulated, banded | 47.8 | 91.6 |
| 193 | Kha-2-27 | | 11.4 | | silty fine sand, alevrit, | dark-grey, brown | banded, broken lenses | 33.2 | 49.6 |
| 194 | Kha-2-28 | | 14.5 | | silty fine sand, alevrit, twigs | dark-grey, brown | lense-like reticulated, banded | 49.3 | 97.1 |
| 195 | Kha-2-29 | | 15.1 | | silty fine sand, alevrit | dark-grey, brown | lense-like reticulated, banded | | |
| 196 | Kha-2-30 | | 15.5 | | silty fine sand, alevrit, organic inclusions | dark-grey, brown | lense-like reticulated, banded | 53.2 | 113.6 |
| 197 | Kha-2-31 | | 16 | | peat inclusion, paleo sol | brownish -grey | lense-like reticulated, banded | 33.7 | 50.8 |
| 198 | Kha-2-32 | | 16.5 | | silty fine sand, alevrit, organic inclusions | brownish -grey | lense-like reticulated, banded | 46.1 | 85.4 |
| 199 | Kha-2-33 | | 16.9 | | silty fine sand, alevrit | dark-grey, brown | lense-like reticulated, banded | | |
| Kka-3, Khardang Island, polozatik ice wedge, 72,94975°N, 124,21307 °E, 30.08.2005 | | | | | | | | | |
| 200 | Kha-3-1 | | 4.5 | | fine sand | yellowish -grey | massive | | |
| 201 | Kha-3-2 | | 4.8 | | peat | brown | massive | | |
| 202 | Kha-3-3 | | 5.4 | | peat | brown | massive | | |
| 203 | Kha-3-4 | | 6.4 | | fine sand, organic, sulphid spots | yellowish -grey, black | massive | | |
| T 021, Turakh Island, sand profile, 73.00 °N, 123.830 °E, 26.08. 2005 | | | | | | | | | |
| 204 | T 021-0 | | | 0.1 | fine to middle sand, dune | grey | unfrozen | | |
| 205 | T 021-1 | | | 0.2 | | grey | unfrozen | | |
| 206 | T 021-2 | | | 0.3 | fine to middle sand, dune, organic, ox. horizon | spotty, brownish | unfrozen | | |
| 207 | T 021-3 | | | 0.35 | fine sand, roots, bedded | yellowish -grey | unfrozen | | |
| 208 | T 021-4 | | | 0.5 | fine sand, organic remains, ox. band | orange, grey | unfrozen | | |
| 209 | T 021-5 | | | 0.7 | fine sand, schlieres | light to dark orange, grey | unfrozen | | |
| 210 | T 021-6 | | | 0.8 | | | | | |
| 211 | T 021-7 | | | 0.9 | fine sand, bedded | orange, grey | unfrozen | | |
| 212 | T 021-8 | | | 1.1 | fine sand, bedded | orange, grey | unfrozen | | |
| 213 | T 021-9 | | | 1.3 | fine sand | orange, grey | frozen, sand wedges, lattice like | 13.0 | 14.9 |
| 214 | T 021-10 | | | 1.6 | fine sand | | | | |
| 215 | T 021-11 | | | 1.8 | fine sand | | | 16.6 | 19.9 |

## **Appendix 4-3:** Modern soil profiles and surface samples

| No | sample | height [m]l | depth [m] | lithology | colour |
|---|---|---|---|---|---|
| **Samoylov Island, 72.3679 °N, 126.4796 °E, 12.08.2006** | | | | | |
| 216 | Sam 1 O | 0.28 | 0 - 0.1 | organic surface material, fine-sand | |
| 217 | Sam 1 Ah | | 0.1 - 0.12 | soil material, silt, sand | 2.5 Y 2.5/1 (Munsell) |
| 218 | Sam 1B1w(M1) | | 0.12 - 0.15 | soil material, silt, sand | 2.5 Y 3/1 |
| 219 | Sam 1 B2wj(M2) | | 0.15 - 0.22 | soil material, silt, sand | 2.5 Y 3/2 |
| 220 | Sam 1 B3jj(M3) | | 0.22 - 0.28 | soil material, silt, sand | 2.5 Y 2.5/1 |
| **Samoylov Island, 72.3712 °N, 126,4748 °E, 12.08.2006** | | | | | |
| 221 | Sam 4 Ah(MAh) | 0.45 | 0 - 0.03 | soil material, fine-sand | 2.5 Y 3/3 |
| 222 | Sam 4 Oi1(fOM) | | 0.03 - 0.06 | soil material, silt, sand | 2.5 Y 2.5/1 |
| 223 | Sam 4 Oi2(fO) | | 0.06 - 0.12 | soil material, peat | 10 YR 3/4 |
| 224 | Sam 4 ABg(AhGo) | | 0.12 - 0.17 | soil material, silt, sand | 2.5 Y 2.5/1 |
| 225 | Sam 4 Bg1(Go) | | 0.17 - 0.22 | soil material, middle-sand | 5 Y 2.5/2 (2.5 YR 2.5/4 rust spots) |
| 226 | Sam 4 Bg2(Gr) | | 0.22 - 0.45 | soil material, fine sand, middle-sand | 3/10 Y |
| | | | | | |
| 227 | Tur Lake 1 | | | drift wood | |
| 228 | Tur Lake 2 | | | drift wood | |
| 229 | Tur Lake 3 | | | drift wood | |
| 230 | Tur Lake 4 | | | drift wood | |
| | | | | | |
| 231 | Tur Lake 5-1 C | 0.6 | 0.5 - 0.6 | soil material, lake deposits, sand | dark greyish |
| 232 | Tur Lake 5-2 L(Fhh) | | 0.3 - 0.5 | soil material, peat, sand, limnic | |
| 233 | Tur Lake 5-3 Oi(Hn2) | | 0.1 - 0.3 | soil material, peat | |
| 234 | Tur Lake 5-4 Oe(Hnb) | | 0 - 0.1 | soil material, peat | |
| 235 | Tur Lake 5-r | | | modern lake surface deposit, sand | |
| | | | | | |
| 236 | Tur Lake 6-1 | | | sand | |
| 237 | Tur Lake 6-2 | | | sand | |
| | | | | | |
| 238 | Tur Lake 7-1 | | | sand | |
| 239 | Tur Lake 7-2 | | | sand | |
| | | | | | |
| 240 | Tur Lake r 2 | | | sand | |
| 241 | Tur Lake r 3 | | | sand | |
| | | | | | |
| 242 | Tur Lake-9-1 Ah(O) | 0.75 | 0 - 0.03 | soil material, fine-sand | |
| 243 | Tur Lake-9-1 Abjj(Abv) | | 0.03 - 0.36 | soil material, middle-sand | |
| 244 | Tur Lake-9-1 Bjj(Cv) | | 0.36 - 0.46 | soil material, middle-sand | |
| 245 | Tur Lake-9-1 Bw(IICv) | | 0.46 - 0.75 | soil material, middle-sand | |
| | | | | | |
| 246 | Tur-Lake 9-2 Ah1(Ah) | 0.8 | 0 - 0.05 | soil material, fine-sand | |
| 247 | Tur-Lake 9-2 Bjj(MCv) | | 0.05 - 0.13 | soil material, middle-sand | |
| 248 | Tur-Lake 9-2 Ah2(fAh) | | 0.13 - 0.2 | soil material, middle-sand | |
| 249 | Tur-Lake 9-2 Bw1(Cv1) | | 0.2 - 0.4 | soil material, middle-sand | |
| 250 | Tur-Lake 9-2 Bw2(Cv2) | | 0.4 - 0.8 | soil material, middle sand | |

**Appendix 4-3:** Continuation

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| 251 | Tur Lake 9-3 Bg1(Go) | 0.7 | 0.03 - 0.12 | soil material, middle-sand | |
| 252 | Tur Lake 9-3 Bg1(Go) | | 0.12 - 0.18 | soil material, middle -sand | |
| 253 | Tur Lake 9-3 Bg2(Gr) | | 0.18 - 0.7 | soil material, middle - sand | |
| 254 | Tur Lake 9-4 O (Hn) | 0.3 | 0 - 0.1 | soil surface material, moos | |
| 255 | Tur Lake 9-4 Bg2(Gr) | | 0.12 - 0.2 | soil material, fine-sand | |
| | | | | | |
| 256 | Tur Lake 10-1 | | | sand | |
| 257 | Tur Lake 10-2 | | | sand | |
| 258 | Tur Lake 10-3 | | | sand | |
| 259 | Tur Lake 10-4 | | | sand | |
| | | | | | |
| 260 | T 027 Ah1(Ah) | 0.65 | 0 - 0.04 | soil material, fine-sand | |
| 261 | T 027 Bjj(MCv) | | 0.04 - 0.1 | soil material, middle-sand | |
| 262 | T 027 Ah2jj(fAh) | | 0.1 - 0.18 | soil material, fine-sand | |
| 263 | T 027 Bw1(Cv1) | | 0.18 - 0.4 | soil material, middle-sand | |
| 264 | T 027 Bw2(Cv2) | | 0.4 - 0.65 | soil material, middle-sand | |
| Ebe Sise Island, alas near the camp, 17./27.08.2005; N 72,97442°, E 123,75547° | | | | | |
| 265 | Ebe Mikropingo | | | peat | |
| 266 | T029-Mikropingo | | | peat | |
| | | | | | |
| 267 | TO20-2 Mikropingo | | | | |

**Appendix 4-4:** List of ground ice and surface water samples

| no. | date | sample no. | composition | high [m] | depth [m] | collector |
|---|---|---|---|---|---|---|
| 1 | 27.08. | Ebe Micropingo | texture ice (same position) | | 0,1 | mathias |
| 2 | 17.08. | T 007 Mikropingo | texture ice | | 0,1 | lutz |
| 3 | 19.08. | Ebe-2-I-1 | segregation ice or ice filled cave | | 0,9 | lutz |
| 4 | 19.08. | Ebe-2-I-2 | segregation ice | | 0,9 | lutz |
| 5 | 19.08. | Ebe-2-I-3 | segregation ice | | 0,9 | lutz |
| 6 | 19.08. | Ebe-2-I-4 | segregation ice | | 0,9 | lutz |
| 7 | 22.08. | Ebe-4-I-1 | ice vein | | 3,2 | lutz |
| 8 | 22.08. | Ebe-4-I-2 | ice vein | | 4,35 | lutz |
| 9 | 22.08. | Ebe-4-I-3 | ice vein | | 4,3 | lutz |
| 10 | 22.08. | Ebe-4-S-10-Texture | texture ice | | 3 | lutz |
| 11 | 22.08. | Ebe-4-S-9-Texture | texture ice | | 2,85 | lutz |
| 12 | 31.08. | Ebe-5-I-1 | ice wedge | | | Tanya |
| 13 | 31.08. | Ebe-5-I-2 | ice wedge | | | Tanya |
| 14 | 31.08. | Ebe-5-1 (texture) | texture ice | 3,2 | | Tanya |
| 15 | 31.08. | Ebe-5-2 (texture) | texture ice | 3,6 | | Tanya |
| 16 | 31.08. | Ebe-5-3 (texture) | texture ice | 3,9 | | Tanya |
| 17 | 31.08. | Ebe-5-4 (texture) | texture ice | 4,05 | | Tanya |
| 18 | 31.08. | Ebe-5-5 (texture) | texture ice | 4,75 | | Tanya |
| 19 | 18.08. | Tur-1-I-1 | ice wedge | | 3,3 | lutz |
| 20 | 18.08. | Tur-1-I-2 | ice wedge | | 3,05 | lutz |
| 21 | 18.08. | Tur-1-I-3 | ice wedge | | 2,95 | lutz |
| 22 | 18.08. | Tur-1-I-4 | ice wedge | | 3,9 | lutz |
| 23 | 18.08. | Tur-1-I-5 | ice wedge | | 2,6 | lutz |
| 24 | 18.08. | Tur-1-I-6 | ice wedge | | 2,2 | lutz |
| 25 | 18.08. | Tur-1-I-7 | ice wedge | | 1,6 | lutz |
| 26 | 18.08. | Tur-1-I-8 | ice wedge | | 3,9 | lutz |
| 27 | 20.08. | Tur-1-I-9 | ice wedge | | 3,9 | lutz |
| 28 | 20.08. | Tur-1-I-10 | ice wedge | | 2,4 | lutz |
| 29 | 20.08. | Tur-1-I-11 | ice wedge | | 2,4 | lutz |
| 30 | 20.08. | Tur-1-I-12 | ice wedge | | 2,4 | lutz |
| 31 | 20.08. | Tur-1-I-13 | ice wedge | | 2,4 | lutz |
| 32 | 20.08. | Tur-1-I-14 | ice wedge | | 2,4 | lutz |
| 33 | 18.08. | Tur-1-2 (texture) | texture ice | | 4 | lutz |
| 34 | 18.08. | Tur-1-3 (texture) | texture ice | | 3,4 | lutz |
| 35 | 18.08. | Tur-1-4 (texture) | texture ice | | 3 | lutz |
| 36 | 18.08. | Tur-e | ice vein | | surface | lutz |
| 37 | 20.08. | Tur-2-1 (texture) | elementar ice vein | | 1,05 | lutz |
| 38 | 20.08. | Tur-2-2 | ice wedge | | 1,2 | lutz |
| 39 | 20.08. | Tur-2-3 (texture) | texture ice | | 1,3 | lutz |
| 40 | 20.08. | Tur-2-4 (texture) | texture ice | | 1,38 | lutz |
| 41 | 20.08. | Tur-2-5 (texture) | texture ice | | 1,45 | lutz |
| 42 | 20.08. | Tur-2-6 (texture) | texture ice | | 1,51 | lutz |
| 43 | 20.08. | Tur-2-7 (texture) | texture ice | | 1,56 | lutz |
| 44 | 20.08. | Tur-2-10 (texture) | texture ice | | 1,95 | lutz |
| 45 | 23.08. | Tur-2-11 (texture) | texture ice | | 2,05 | lutz |
| 46 | 23.08. | Tur-2-13 (texture) | texture ice | | 2,25 | lutz |
| 47 | 23.08. | Tur-2-14 (texture) | texture ice | | 2,35 | lutz |
| 48 | 24.08. | Tur-2-37 (texture) | texture ice | | 5,75 | lutz |
| 49 | 24.08. | Tur-2-38 (texture) | texture ice | | 5,8 | lutz |
| 50 | 24.08. | Tur-2-39 (texture) | ice wedge | | 5,85 | lutz |

**Appendix 4-4:** Continuation

| no. | sample date | sample no. | composition | Higth [m] | depth [m] | collector |
|---|---|---|---|---|---|---|
| 51 | 26.08. | Kha-1-I-1 | fracture filling | | | lutz |
| 52 | 26.08. | Kha-2-I-1 | polozatic ice | | 6,8 | lutz |
| 53 | 26.08. | Kha-2-I-2 | polozatic ice | | 6,77 | lutz |
| 54 | 26.08. | Kha-2-I-3 | polozatic ice | | 6,74 | lutz |
| | 26.08. | Kha-2-I-4 | polozatic ice | | 7,3 | lutz |
| 55 | 30.08. | Kha-2-12 (texture) | texture ice | | 6,5 | lutz |
| 56 | 30.08. | Kha-2-14 (texture) | texture ice | | 6,9 | lutz |
| 57 | 30.08. | Kha-2- 16 (texture) | texture ice | | 7,8 | lutz |
| 58 | 30.08. | Kha-2-18 (texture) | texture ice | | 8,6 | lutz |
| 59 | 30.08. | Kha-2-20 (texture) | texture ice | | 8,2 | lutz |
| 60 | 30.08. | Kha-2-22 (texture) | texture ice | | 9,2 | lutz |
| 61 | 30.08. | Kha-2-23 (texture) | texture ice | | 9,8 | lutz |
| 62 | 30.08. | Kha-2-24 (texture) | texture ice | | 10,1 | lutz |
| 63 | 30.08. | Kha-2-26 (texture) | texture ice | | 11 | lutz |
| 64 | 30.08. | Kha-2-27 (texture) | texture ice | | 11,4 | lutz |
| 65 | 30.08. | Kha-2-28 (texture) | texture ice | | 14,5 | lutz |
| 66 | 30.08. | Kha-2-30 (texture) | texture ice | | 15,5 | lutz |
| 67 | 30.08. | Kha-2-31 (texture) | texture ice | | 16 | lutz |
| 68 | 30.08. | Kha-2-32 (texture) | texture ice | | 16,5 | lutz |
| 69 | 30.08. | Kha-2-33 (texture) | texture ice | | 16,9 | lutz |
| 70 | 30.08. | Kha-3-1 (texture) | texture ice | | 0,5 | lutz |
| 71 | 30.08. | Kha-3-I-1 | polozatic ice | | 4,5 | lutz |
| 72 | 30.08. | Kha-3-I-2 | polozatic ice | | 4,5 | lutz |
| 74 | 30.08. | Kha-3-I-3 | polozatic ice | | 4,5 | lutz |
| 75 | 30.08. | Kha-3-I-4 | polozatic ice | | 6,4 | lutz |
| 76 | 30.08. | Kha-3-I-5 | polozatic ice | | 6,4 | lutz |
| 77 | 30.08. | Kha-3-I-6 | polozatic ice | | 6,4 | lutz |
| 78 | 30.08. | Kha-3-I-7 | polozatic ice | | 6,4 | lutz |
| 79 | 30.08. | Kha-3-I-8 | polozatic ice | | 7,5 | lutz |
| 80 | 30.08. | Kha-3-I-9 | polozatic ice | | 7,5 | lutz |
| 81 | 30.08. | Kha-3-I-10 | polozatic ice | | 7,5 | lutz |
| 82 | 30.08. | Kha-3-I-11 | polozatic ice | | 7,5 | lutz |
| 83 | 24.08. | Tur-Lake r2 | lake water | | | guido |
| 84 | 27.08. | North Tur Lake | lake water, 1st Lake Turakh Island | | | guido |
| 85 | 26.08. | T 020 Tur-Lake Mikropingo | segregation ice | | | hugues |
| 86 | 26.08. | T 020 Sediment Mikropingo | texture ice | | | hugues |
| 87 | 31.08. | Tur-Lake 10-W 1 | lake water | | | hugues |
| 88 | 31.08. | Tur-Lake 10-W 2 | lake water | | | hugues |

**Appendix 4-5:** Bones collection from the expedition LENA 2005

| No. | N samples | Taxon | Skeleton element | Preservation | Location type | Locality | Collector |
|---|---|---|---|---|---|---|---|
| Kurungnakh Island, Buor-Khaya locality | | | | | | | |
| 1 | BKh-05-O1 | Rangifer tarandus | calcaneus | | c | Kurungnakh Isl.., Buor-Khaya locality; outcrop | samples O1 - O3 from one individual, probably; recent ? |
| 2 | BKh-05-O2 | Rangifer tarandus | astrogalus | | c | Kurungnakh Isl.., Buor-Khaya locality; outcrop | |
| 3 | BKh-05-O3 | Rangifer tarandus | centrotarsale | | c | Kurungnakh Isl.., Buor-Khaya locality; outcrop | |
| 4 | BKh-05-O4 | Mammuthus primigenius | tusk | fragment | a | In situ, large thermocircus, boundary betwen Ice Complex and lower sand | non collect |
| 5 | BKh-05-O5 | Mammuthus primigenius | humerus | fragment | c | Kurungnakh Il.s., Buor-Khaya locality; outcrop | trashed |
| 6 | BKh-05-O28 | Mammuthus primigenius | Mc I | | c | Kurungnakh Isl.., Buor-Khaya locality; outcrop | from Meyer H. |
| 7 | BKh-05-O29 | Large herbivorus mammal | costa | | c | Kurungnakh I.s., Buor-Khaya locality; outcrop | from Meyer H., trashed |
| 8 | BKh-05-O30 | Ovibos moschatus ? | ph II | | c | Kurungnakh Is., Buor-Khaya locality; outcrop | from Meyer H. |
| 9 | BKh-05-O31 | Equus caballus | pelvis | fragment, left | c | Kurungnakh Is., Buor-Khaya locality; outcrop | from Meyer H. |

**Appendix 4-5:** Continuation

| No. | N samples | Taxon | Skeleton element | Preservation | Location type | Locality | Collector |
|---|---|---|---|---|---|---|---|
| Khardang Island, Arynskaya Channel | | | | | | | |
| 1 | Kha-O6 | Bison priscus | Mc | | d | Khardang Isl., shore | |
| 2 | Kha-O7 | Mammuthus primigenius | femur | proximal fragment | b | Knardang Isl., exposure, 3 m below the tundra surface | juv., C14 |
| 3 | Kha-O8 | Mammuthus primigenius | radius | fragment | c | Khardang Isl., outcrop | small |
| 4 | Kha-O9 | Rangifer tarandus | radius | distal fragment with marrow | c | Khardang Isl., outcrop, middle part of stream | from Kunitsky V. V. |
| 5 | Kha-O10 | Equus caballus | pelvis | fragment | c | Khardang Isl., outcrop | |
| 6 | Kha-O11 | Rangifer tarandus | sacrum | fragment | d | Khardang Isl., shore | recent?, juv., trashed |
| 7 | Kha-O12 | Large herbivorus mammal | costa | fragment | c | Khardang Isl., outcrop | trashed |
| 8 | Kha-O13 | Large herbivorus mammal | limb bone | fragment | c | Khardang Isl., outcrop | from Kunitsky V.V., trashed |
| 9 | Kha-O14 | Martes sp.? | mandibula with teeth | fragment | d | Khardang Isl., shore | |
| 10 | Kha-O15 | Lepus sp. | tibia | distal fragment (2 pieces) | b | Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface | samples O15 - O17 from one individual; juv |
| 11 | Kha-O16 | Lepus sp. | calcaneus | | b | Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface | |

**Appendix 4-5:** Continuation

| No. | N samples | Taxon | Skeleton element | Preservation | Location type | Locality | Collector |
|---|---|---|---|---|---|---|---|
| 12 | Kha-O17 | Lepus sp. | astrogalus? | | b | Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface | |
| 13 | Kha-O18 | Mammuthus primigenius | fibula | fragment | c | Khardang Isl., exposure, middle part | juv. |
| 14 | Kha-O19 | Rangifer tarandus | os carpale II+III | | c | Khardang Isl., exposure, middle part | recent? |
| 15 | Kha-O20 | Lepus sp. | ulna | fragment | c | Khardang Isl., exposure, middle part | recent? |
| 16 | Kha-O21 | Lepus sp. | scapula | fragment | c | Khardang Isl., exposure, middle part | recent?, from Kunitsky V.V. |
| 17 | Kha-O22 | Mammuthus primigenius ? | limb bone | fragment (2 pieces) | b | Khardang Isl., exposure, 5,5 m above river level, profile № 2; above peet, in unfrozen sediments | from Schirrmeister L.; trashed |
| 18 | Kha-O23 | Equus sp. | tibia | fragment (2 pieces) | c | Khardang Isl., exposure, middle part | trashed |
| 19 | Kha-O24 | Ancer albiferens | humerus ? | damaged | b | Khardang Isl., exposure, 1,2 m below the tundra surface | samples O24 - O27 from one individual; recent?; from Kunitsky V.V. |
| 20 | Kha-O25 | Ancer albiferens | clavicula ? | | b | Khardang Isl., exposure, 1,2 m below the tundra surface | |
| 21 | Kha-O26a | Ancer albiferens | costa | | b | Khardang Isl., exposure, 1,2 m below the tundra surface | |
| 22 | Kha-O26b | Ancer albiferens | costa | | b | Khardang Isl., exposure, 1,2 m below the tundra surface | |
| 23 | Kha-O27 | Ancer albiferens | vertebra spine | fragment | b | Khardang Isl., exposure, 1,2 m below the tundra surface | |

**Appendix 4-6:** Bone collection of Lena Delta Reserve Tiksi (see chapter 4.8)

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 1 | LDR - O1 | Bison priscus | cranium with horn cores | | Lena Delta Region | Bykovsky Peninsula, Van'kina bay | Gukov A. Yu. | 1996 | |
| 2 | LDR - O2 | Bison priscus | cranium with horn cores | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 3 | LDR - O3 | Mammuthus primigenius | mandible with teeth | damaged | Dmitriy Laptev Strait | Rebrova R. | Andreyuk A. N. | 2003 | |
| 4 | LDR - O4 | Mammuthus primigenius | mandible with teeth | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Rotkin I. N. | 2002 | |
| 5 | LDR - O5 | Mammuthus primigenius | mandible with teeth | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Dubov A. E. | 2002 | |
| 6 | LDR - O6 | Mammuthus primigenius | tooth | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Polyansky A. S. | 2000 | |
| 7 | LDR - O7 | Mammuthus primigenius | tooth | damaged | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 2002 | |
| 8 | LDR - O8 | Bison priscus | cranium with left horn core | fragment | Yana Bay | Makar Isl., "Makar" polar station | Yarlykov Yu. A. | 1985 | |
| 9 | LDR - O9 | Mammuthus primigenius | tooth | | New Siberian Islands | New Siberian Isl., Goristy Cape | Yakshina I. A. | 2002 | |
| 10 | LDR - O10 | Mammuthus primigenius | tooth | fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Polyansky A. S. | 2000 | |
| 11 | LDR - O11 | Ursus arctos | humerus | | New Siberian Islands | Faddeevsky Isl., Blagoveshchensky Cape | Yakshina I. A. | 2003 | determination of Nikol'sky P. A. |
| 12 | LDR - O12 | Panthera cf. spelaear | sacrum+pelvis with copulas | | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 2001 | determination of Nikol'sky P. A. |
| 13 | LDR - O13 | Bison priscus | cranium with horn cores | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Stryuchkov V. N. | 2002 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 14 | LDR - O14 | Mammuthus primigenius | mandible with milk teeth | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Volkov S. Yu. | 2002 | juv., samples: O14, O15 - from one individual, probably |
| 15 | LDR - O15 | Mammuthus primigenius | cranium with two milk teeth, two tusks | fragment (6 pieces of cranium and 2 pieces of milk teeth) | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Volkov S. Yu. | 2002 | |
| 16 | LDR - O17 | Bison priscus | lower tooth (M3) | | | Muostakh Isl. | Larionov S. V. | 1994 | field № 48 |
| 17 | LDR - O18 | Equus sp. | femur, right | damaged | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 18 | LDR - O19 | Equus sp. | cranium with P2-M3, C and I3 | damaged | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 19 | LDR - O20 | Bison priscus | mandible, right stem with all teeth | | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 20 | LDR - O21 | Equus sp. | mandible with right M1-M3, C and left P4-M3, C, I3 | | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | sore |
| 21 | LDR - O22 | Bison priscus | thorax vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Polyansky A. S. | 2000 | |
| 22 | LDR - O23 | Equus sp. | scapula, right | fragment | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 23 | LDR - O24 | Equus sp. | femur, left | damaged | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 24 | LDR - O25 | Equus sp. | radius, left | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Abramov A. A. | 1996 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 25 | LDR - O26 | Bison priscus | tibia | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2002 | |
| 26 | LDR - O27 | Mammuthus primigenius | thorax vertebra | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Stryuchkov V. N. | 2002 | |
| 27 | LDR - O28 | Ovibos moschatus | cranium, male | fragment | New Siberian Islands | New Siberian Isl., Pestsoviy Cape | Yakshina I. A. | 2001 | |
| 28 | LDR - O29 | Bison priscus | atlas | | Yana Bay | Makar Isl., "Makar" polar station | Yarlykov Yu. A. | 1985 | |
| 29 | LDR - O30 | Mammuthus primigenius | scapula, right | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2002 | |
| 30 | LDR - O31 | Mammuthus primigenius | mandible without teeth, right stem | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Dubov A. E. | 2002 | field № - 184 |
| 31 | LDR - O32 | Mammuthus primigenius | tibia | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | |
| 32 | LDR - O33 | Mammuthus primigenius | mandible | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2002 | |
| 33 | LDR - O34 | Mammuthus primigenius | mandible without teeth | fragment | Lena Delta Region | Bykovsky Peninisula, Mamontovaya Khayata | Safonov Yu. N. | 2001 | |
| 34 | LDR - O35 | Mammuthus primigenius | mandible with right and left teeth | damaged | Dmitriy Laptev Strait | Khaptashinskiy Yar | Andreyuk A. N. | 2002 | |
| 35 | LDR - O36 | Mammuthus primigenius | mandible without teeth, left stem | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Rotkin I. N. | 2002 | |
| 36 | LDR - O37 | Ovibos moschatus | atlas | | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 37 | LDR - O38 | Mammuthus primigenius | scapula | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 38 | LDR - O39 | Mammuthus primigenius | mandible with teeth | fragment | New Siberian Islands | New Siberian Isl., Pestsoviy Cape | Yakshina I. A. | 2001 | |
| 39 | LDR - O40 | Equus sp. | femur, right | | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 40 | LDR - O41 | Mammuthus primigenius | tibia | distal fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 41 | LDR - O42 | Mammuthus primigenius | cranium (alveola) | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2002 | |
| 42 | LDR - O43 | Mammuthus primigenius | humerus | proximal fragment | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | |
| 43 | LDR - O44 | Coelodonta antiquitatis | mandible, left stem with P4 - M3 | | Yana River Region | Mus-Khaya outcrop | Yakshina I. A. | 2003 | AMS, teeth heavily worn |
| 44 | LDR - O45 | Mammuthus primigenius | scapula, right | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Dedyukin A. N. | 2002 | |
| 45 | LDR - O48 | Equus sp. | upper tooth (M1), right | | New Siberian Islands | New Siberian Isl., Rozhina Cape | Yakshina I. A. | 2000 | heavily worn |
| 46 | LDR - O49 | Mammuthus primigenius | small bone of tarsale | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 47 | LDR - O50 | Mammuthus primigenius | mandible with milk teeth | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Volkov S. Yu. | 2002 | juv. |
| 48 | LDR - O51 | Bison priscus | horn sheet | | Yana Bay | Makar Isl., "Makar" polar station | Yarlykov Yu. A. | 1985 | |
| 49 | LDR - O52 | Bison priscus? | metacarpate | | | O. M. P. | | | |
| 50 | LDR - O53 | Mammuthus primigenius | tibia | fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | juv. |
| 51 | LDR - O54 | Bison priscus | thorax vertebra | | Yana Bay | Makar Isl., "Makar" polar station | Yarlykov Yu. A. | 1985 | |
| 52 | LDR - O55 | Bison priscus | epistropheus | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 53 | LDR - O56 | Bison priscus | metacarpate | | | | | | |
| 54 | LDR - O57 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 55 | LDR - O58 | Mammuthus primigenius | lumbar vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 56 | LDR - O59 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Polyansky A. S. | 2000 | |
| 57 | LDR - O60 | Mammuthus primigenius | epistropheus | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | juv. |
| 58 | LDR - O61 | Mammuthus primigenius | tooth | | New Siberian Islands | New Siberian Isl., Goristy Cape | Yakshina I. A. | 2002 | |
| 59 | LDR - O62 | Mammuthus primigenius | tooth | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 60 | LDR - O63 | Bison priscis | thorax vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 61 | LDR - O64 | Mammuthus primigenius | atlas | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Lysak V. A. | 1998 | |
| 62 | LDR - O65 | Mammuthus primigenius | tusk | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Rotkin I. N. | 2002 | field № - A-102 |
| 63 | LDR - O66 | Mammuthus primigenius | femur | proximal fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | juv. |
| 64 | LDR - O67 | Mammuthus primigenius | scapula | fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | |
| 65 | LDR - O68 | Equus sp. | cranium with all teeth | damaged | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | |
| 66 | LDR - O69 | Equus sp. | mandible, right stem with M1 - M3 | fragment | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | |
| 67 | LDR - O70 | Equus sp. ? | costa | | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Ponyavin V. N. | 1987 | |
| 68 | LDR - O139 | Mammuthus primigenius | fibula | distal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 69 | LDR - O141 | Mammuthus primigenius | small lib bone | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 70 | LDR - O143 | Mammuthus primigenius | metapodiale | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 71 | LDR - O144 | Mammuthus primigenius | tibia | fragment, proximal articulation | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | juv. |
| 72 | LDR - O146 | Mammuthus primigenius | costa | fragment | Lena Delta Region | Bykovsky PENINSULA, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 73 | LDR - O156 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | strong lateral asymmetry |
| 74 | LDR - O181 | Ovibos moschatus | cranium left and right teeth P4 - M3, male | damaged | New Siberian Islands | New Siberian Isl., Pestsoviy Cape | Yakshina I. A. | 2001 | |
| 75 | LDR - O201 | Bison priscus | femur, left | distal articulation | Lena Delta Region | Sardakh-Ary Isl. | Gukov A. Yu. | 1999 | juv. |
| 76 | LDR - O202 | Bison priscus | astrogalus | | New Siberian Islands | Anzhu Spit, near Glubikoe Lake | Rizhiy S. N. | 2002 | |
| 77 | LDR - O203 | Bison priscus | antebrachium, left | | New Siberian Islands | Anzhu Spit, near Glubikoe Lake | Rizhiy S. N. | 2002 | |
| 78 | LDR - O204 | Bison priscus | thorax vertebra | damaged | New Siberian Islands | Anzhu Spit, near Glubikoe Lake | Rizhiy S. N. | 2002 | |
| 79 | LDR - O205 | Bison priscus | thorax vertebra | damaged | New Siberian Islands | Anzhu Spit, near Glubikoe Lake | Rizhiy S. N. | 2002 | |
| 80 | LDR - O206 | Mammuthus primigenius | fibula | fragment, without distal articulation | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | juv. |
| 81 | LDR - O207 | Equus sp. | cervical vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |

**Appendix 4-6.** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 82 | LDR - O208 | Equus sp. | Mt III, left | | Olenek R. | left bank of Olonek R., Taimylyr vil., tundra surface | Krasovskiy S. E. | 2001 | |
| 83 | LDR - O209 | Equus sp. | scapula | damaged | Lena Delta Region | Sobo-Sise Isl. | Klimenko A. N. | 2000 | |
| 84 | LDR - O210 | Equus sp. | Mc III, right | proximal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 85 | LDR - O211 | Rangifer tarandus | Mt III | fragment, without distal articulatio n | Lena Delta Region | Kurungnakh-Sise Isl., | Gukov A. Yu. | 2000 | juv. |
| 86 | LDR - O212 | Rangifer tarandus | tibia | fragment | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1998 | |
| 87 | LDR - O213 | Rangifer tarandus | thorax vertebra | damaged | New Siberian Islands | Kotel'niy Isl., Medvezhiy Cape, Sannikov polar station | Rizhiy S. N. | 2001 | juv. |
| 88 | LDR - O214 | Ovibos sp.? | metacarpate | fragment, without distal articulatio n | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1998 | |
| 89 | LDR - O215 | Equus sp. | atlas | damaged | New Siberian Islands | Kotel'niy Isl., Medvezhiy Cape, Sannikov polar station | Rizhiy S. N. | 2001 | |
| 90 | LDR - O216 | Bison priscus | cranium with fragment of left horn | fragment (2 pieces) | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Nikol'skiy P. A. | 2001 | field № MKh 01-8; determination of Nikol'skiy P. A. |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preservation | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 91 | LDR - O217 | Bison priscus | astrogalus | | Lena Delta Region | Bykovsky Peninsula, east coast, Bykov Cape | Gukov A. Yu. | 1995 | determination of Nikol'skiy P. A. |
| 92 | LDR - O218 | Bison priscus | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, east coast, Bykov Cape | Gukov A. Yu. | 1996 | determination of Nikol'skiy P. A. |
| 93 | LDR - O219 | Cervus elaphus | atlas | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | determination of Sher A. V. |
| 94 | LDR - O220 | Bison priscus | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, east coast, Bykov Cape | Gukov A. Yu. | 1997 | determination of Nikol'skiy P. A. |
| 95 | LDR - O221 | Bison priscus | antebrachium, left | fragment, without proximal articulation | Lena Delta Region | Kurungnakh-Sise Isl., Buor-Khaya loc. | Gukov A. Yu. | 1996 | determination of Nikol'skiy P. A. |
| 96 | LDR - O222 | Bison priscus | tibia, right | | Tiksi Bay | Razdel'niy Cape | Gukov A. Yu. | 1991 | determination of Nikol'skiy P. A. |
| 97 | LDR - O223 | Bison priscus | humerus, left | damaged | Tiksi Bay | Razdel'niy Cape | Gukov A. Yu. | 1991 | determination of Nikol'skiy P. A. |
| 98 | LDR - O224 | Bison priscus | pelvis, left | fragment | Tiksi Bay | Razdel'niy Cape | Gukov A. Yu. | 1991 | determination of Nikol'skiy P. A. |
| 99 | LDR - O225 | Bison priscus | humerus, left | | Tiksi Bay | Razdel'niy Cape | Gukov A. Yu. | 1991 | |
| 100 | LDR - O226 | Rangifer tarandus | cranium with fragment of left antler | fragment | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1990 | juv. |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 101 | LDR - O227 | Rangifer tarandus ? | cranium with fragment of right antler | fragment | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1990 | |
| 102 | LDR - O228 | Ovibos moschatus | cranium with horn cores | | Olenek R. | Taimylyr vil. | Krasovskiy S. E. | 1988 | male |
| 103 | LDR - O230 | Mammuthus primigenius | atlas | damaged | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1990 | |
| 104 | LDR - O231 | Ovibos moschatus | cranium with left horn core | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Rizhiy S. N. | 2001 | female |
| 105 | LDR - O232 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | samples: O156, O232, O233, O234, O235, O236, O237 - from one individuum, probably |
| 106 | LDR - O233 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 107 | LDR - O234 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 108 | LDR - O235 | Mammuthus primigenius | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | strong asymmetry |
| 109 | LDR - O236 | Mammuthus primigenius | thorax vertebra ? | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 110 | LDR - O237 | Mammuthus primigenius | thorax vertebra ? | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 111 | LDR - O238 | Mammuthus primigenius | cervical vertebra with copulas | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | small |

**Appendix 4-6.** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 112 | LDR - O239 | Mammuthus primigenius | cervical vertebra with copulas | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | small |
| 113 | LDR - O240 | Mammuthus primigenius | epistropheus | | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | small |
| 114 | LDR - O241 | Mammuthus primigenius | cervical vertebra with copulas | | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | samples: O238, O239, O240, O241, O242, O243 - from one individual, probably |
| 115 | LDR - O242 | Mammuthus primigenius | cervical vertebra with copulas | | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | |
| 116 | LDR - O243 | Mammuthus primigenius | tooth | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Manzyuk I. P. | 2004 | |
| 117 | LDR - O244 | Mammuthus primigenius | tooth | damaged | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | |
| 118 | LDR - O245 | Mammuthus primigenius | tooth | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 119 | LDR - O246 | Mammuthus primigenius | tooth | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 120 | LDR - O247 | Mammuthus primigenius | tooth | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 121 | LDR - O248 | Mammuthus primigenius | tooth | fragment | Lena Delta Region | Bykovsky Peninsula, Koryakinskoe L. | Volkov E. D. | 2001 | |
| 122 | LDR - O249 | Bison priscus | cranium with right horn core | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 123 | LDR - O250 | Mammuthus primigenius | humerus | proximal fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1985 | |
| 124 | LDR - O251 | Rangifer tarandus | cranium | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1985 | juv. |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 125 | LDR - O252 | Equus sp. | mandible, left stem with P2 - P3 | fragment | Lena Delta Region | Singir-Aryta Isl. | Polyanskiy A. S. | 2000 | |
| 126 | LDR - O253 | Equus sp. | mandible, left stem with C, P2 - P4 | fragment | Lena Delta Region | Singir-Aryta Isl. | Polyanskiy A. S. | 2000 | sore |
| 127 | LDR - O254 | Equus sp. | cranium, maxilla left stem with P2 - M3, right stem with P4 - M3 | fragment (4 pieces) | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 2000 | |
| 128 | LDR - O255 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Sellyakhov F. V. | 2002 | |
| 129 | LDR - O256 | Equus sp. | ulna, right | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Sellyakhov F. V. | 2002 | |
| 130 | LDR - O257 | Mammuthus primigenius | thorax vertebra | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 131 | LDR – O258 | Mammuthus primigenius | metacarpal bone | | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 132 | LDR - O259 | Mammuthus primigenius | metapodium | | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 133 | LDR - O260 | Mammuthus primigenius | tooth | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 134 | LDR - O261 | Mammuthus primigenius | costa | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 135 | LDR - O262 | Mammuthus primigenius | costa | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 136 | LDR - O263 | Mammuthus primigenius | 1-st costa, right ? | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |
| 137 | LDR - O264 | Mammuthus primigenius | scapula | fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | small, juv.? |
| 138 | LDR - O265 | Equus sp. | Mt III, left | | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1999 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 139 | LDR - O266 | Mammuthus primigenius | humerus | damaged | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | |
| 140 | LDR - O267 | Mammuthus primigenius | thorax vertebra | damaged (2 pieces) | | Muostakh Isl. | Larionov S. V. | 1998 | juv. |
| 141 | LDR - O268 | Mammuthus primigenius | scapula, left with copulas | damaged | Lena Delta Region | Malyga-Sise Isl. | Gukov A. Yu. | 1998 | small, samples: O268, O269 - from one individual, probably |
| 142 | LDR - O269 | Mammuthus primigenius | scapula, left with copulas | 2 pieces | Lena Delta Region | Malyga-Sise Isl. | Gukov A. Yu. | 1998 | |
| 143 | LDR - O270 | Mammuthus primigenius | ulna | fragment | Lena Delta Region | Dzhangylakh Isl. | Gukov A. Yu. | 1998 | |
| 144 | LDR - O271 | Bison priscus | cranium with horn cores | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 145 | LDR - O272 | Mammuthus primigenius | femur | proximal articulatio n | | Muostakh Isl., Severniy Cape | Gukov A. Yu. | 2004 | juv. |
| 146 | LDR - O273 | Mammuthus primigenius | mandible, symphysis | fragment | | Muostakh Isl., Severniy Cape | Gukov A. Yu. | 2004 | |
| 147 | LDR - O274 | Mammuthus primigenius | fibula | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 148 | LDR - O275 | Mammuthus primigenius | tooth | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 149 | LDR - O276 | Mammuthus primigenius | mandible without teeth | fragment (2 pieces) | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Grishkina V. P. | 1988 | with marrow |
| 150 | LDR - O277 | Mammuthus primigenius | pelvis, left part | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Yakovlev A. A. | 2001 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 151 | LDR - O278 | Mammuthus primigenius | cranium | fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | determination of Nikol'skiy P. A. |
| 152 | LDR - O279 | Mammuthus primigenius | scapula, left | damaged | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | small, determination of Nikol'skiy P. A. |
| 153 | LDR - O280 | Mammuthus primigenius | costa | fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | determination of Nikol'skiy P. A. |
| 154 | LDR - O281 | Mammuthus primigenius | pelvis, right part | fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | determination of Nikol'skiy P. A. |
| 155 | LDR - O282 | Mammuthus primigenius | scapula | fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | |
| 156 | LDR - O283 | Mammuthus primigenius | humerus | distal fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | |
| 157 | LDR - O284 | Mammuthus primigenius | humerus | distal fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | |
| 158 | LDR - O285 | Mammuthus primigenius | humerus | fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | juv. |
| 159 | LDR - O286 | Bison priscus | femus, right | proximal fragment | Tiksi Bay | Razdel'niy Cape | Yarlykov Yu. A. | 1986 | |
| 160 | LDR - O287 | Mammuthus primigenius | femur | distal fragment | Lena Delta Region | Bykovsky Peninsula, Ivashkina Lagoon | Gukov A. Yu. | 1998 | |
| 161 | LDR - O288 | Mammuthus primigenius | humerus without proximal articulation | damaged | Lena Delta Region | Bykovsky Peninsula, Kolychev isthmus | Postanogov I. N. | 2004 | juv. |
| 162 | LDR - O289 | Mammuthus primigenius | atlas | damaged | | Muostakh Isl. | Larionov S. V. | 1990 | |
| 163 | LDR - O290 | Mammuthus primigenius | epistropheus | damaged | | Muostakh Isl. | Gukov A. Yu. | 1998 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 164 | LDR - O291 | Mammuthus primigenius | cervical vertebra | damaged | | Muostakh Isl. | Gukov A. Yu. | 1998 | |
| 165 | LDR - O292 | Mammuthus primigenius | lumbar vertebra | | | Muostakh Isl. | Gukov A. Yu. | 1998 | |
| 166 | LDR - O293 | Mammuthus primigenius | humerus | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | juv., determination of Nikol'skiy P. A. |
| 167 | LDR - O294 | Mammuthus primigenius | tibia | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | juv., with traces of carnivora's tooth |
| 168 | LDR - O295 | Mammuthus primigenius | thorax vertebra | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | with traces of carnivora's tooth |
| 169 | LDR - O296 | Mammuthus primigenius | vertebra | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | with traces of carnivora's tooth |
| 170 | LDR - O297 | Mammuthus primigenius | calcaneum | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | with traces of carnivora's tooth |
| 171 | LDR - O298 | Mammuthus primigenius | pelvis, right part | fragment | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | |
| 172 | LDR - O299 | Mammuthus primigenius | abtebrachium | | Lena Delta Region | Sobo-Sise Isl. | Gukov A. Yu. | 1990 | small, AMS |
| 173 | LDR - O300 | Rangifer tarandus | cranium with fragment of left antler | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 174 | LDR - O301 | Rangifer tarandus | antler | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 175 | LDR - O302 | Mammuthus primigenius | tibia | distal fragment | Lena Delta Region | Sobo-Sise Isl., Krestyakh outcrop | Gukov A. Yu. | 1990 | |
| 176 | LDR - O303 | Rangifer tarandus | shed antler | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 177 | LDR - O304 | Rangifer tarandus | thorax vertebra | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 178 | LDR - O305 | Equus sp. | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 179 | LDR - O306 | Rangifer tarandus | scapula | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 180 | LDR - O307 | Rangifer tarandus | tibia | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | juv., DNA |
| 181 | LDR - O308 | Rangifer tarandus | metacarpate | distal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 182 | LDR - O309 | Equus sp. | pelvis, right part | fragment | Lena Delta Region | Sobo-Sise Isl. | Klimenko A. N. | 2000 | juv. |
| 183 | LDR - O310 | Mammuthus primigenius | cranium | fragment | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | |
| 184 | LDR - O311 | Rangifer tarandus | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 185 | LDR - O312 | Mammuthus primigenius | humerus without proximal articulation | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V., Yakovlev A. A. | 2001 | juv., with traces of carnivora's tooth |
| 186 | LDR - O313 | Mammuthus primigenius | pelvis, right part | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 2002 | |
| 187 | LDR - O314 | Mammuthus primigenius | humerus | damaged | Lena Delta Region | Bykovsky Peninsula, Koryakinskoe L. | Yakovlev A. A. | 1988 | with traces of carnivora's tooth |
| 188 | LDR - O315 | Mammuthus primigenius | tibia | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Yakovlev A. A. | 2001 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preservation | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 189 | LDR - O316 | Mammuthus primigenius | radiale | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Yakovlev A. A. | 2001 | |
| 190 | LDR - O317 | Mammuthus primigenius | metapodium | proximal fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Yakovlev A. A. | 2001 | |
| 191 | LDR - O318 | Mammuthus primigenius | epistropheus | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Yakovlev A. A. | 2001 | |
| 192 | LDR - O319 | Mammuthus primigenius | costa | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 193 | LDR - O320 | Mammuthus primigenius | costa | damaged (2 pieces) | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | samples: O320, O321, O322, O323, O324, O329, O330, O331, O332, O336 - from one individual, probably |
| 194 | LDR - O321 | Mammuthus primigenius | costa (2 pieces) | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 195 | LDR - O322 | Mammuthus primigenius | costa (2 pieces) | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 196 | LDR - O323 | Mammuthus primigenius | costa | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 197 | LDR - O324 | Mammuthus primigenius | costa | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 198 | LDR - O325 | Mammuthus primigenius | costa without articulation | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | juv., samples: O325, O326 - from one individual, probably |
| 199 | LDR - O326 | Mammuthus primigenius | costa without articulation | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 200 | LDR - O327 | Mammuthus primigenius | costa without articulation | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | juv. |
| 201 | LDR - O328 | Mammuthus primigenius | costa without articulation | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | juv. |
| 202 | LDR - O329 | Mammuthus primigenius | costa | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 203 | LDR - O330 | Mammuthus primigenius | costa | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 204 | LDR - O331 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 205 | LDR - O332 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 206 | LDR - O333 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 207 | LDR - O334 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 208 | LDR - O335 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 209 | LDR - O336 | Mammuthus primigenius | costa | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2000 | |
| 210 | LDR - O337 | Mammuthus primigenius | cranium | fragment | Lena Delta Region | Muostakh Isl., Severniy Cape | Rotkin I. N. | 2002 | |
| 211 | LDR - O338 | Mammuthus primigenius | thorax vertebra | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | juv. |
| 212 | LDR - O339 | Mammuthus primigenius | thorax vertebra | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | juv. |
| 213 | LDR - O340 | Equus sp. | lower tooth (M1or M2) | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukova N. V. | 2001 | |
| 214 | LDR - O341 | Equus sp. | astrogalus | | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | very fresh preservation |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 215 | LDR - O342 | Equus sp. | ph I | | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | rounded |
| 216 | LDR - O343 | Equus sp. | humerus, left | damaged | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | |
| 217 | LDR - O344 | Equus sp. | humerus, right | | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | |
| 218 | LDR - O345 | Equus sp. | humerus, right without proximal articulation | fragment | Lena Delta Region | Dzhingylakh Isl. | Gukov A. Yu. | 1998 | juv. |
| 219 | LDR - O346 | Equus sp. | ulna, left | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | |
| 220 | LDR - O347 | Rangifer tarandus | calcaneum | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | |
| 221 | LDR - O348 | Rangifer tarandus | metacarpate | damaged | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | recent?, with marrow |
| 222 | LDR - O349 | Rangifer tarandus | pelvis, left part | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | |
| 223 | LDR - O350 | Rangifer tarandus | astrogalus | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | recent? |
| 224 | LDR - O351 | Rangifer tarandus | ph I | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Efimov S. N. | 1985 | |
| 225 | LDR - O352 | Rangifer tarandus ? | atlas | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 226 | LDR - O353 | Equus sp. | cervical vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | juv. |
| 227 | LDR - O354 | Equus sp. | cervical vertebra | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 228 | LDR - O355 | Equus sp. ? | cervical vertebra | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 229 | LDR - O356 | Equus sp. | humerus, right | | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 230 | LDR - O357 | Equus sp. | humerus, right | distal fragment (2 pieces) | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | juv., very fresh preservation |
| 231 | LDR - O358 | Equus sp. | tibia, right | distal fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 232 | LDR - O359 | Equus sp. | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 233 | LDR - O360 | Rangifer tarandus | femur, left | distal fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 234 | LDR - O361 | Rangifer tarandus | thorax vertebra | fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | |
| 235 | LDR - O362 | Rangifer tarandus | radius, left | proximal fragment | Lena Delta Region | Bykovsky Peninsula, Muostakh Cape | Gukov A. Yu. | 1998 | juv. |
| 236 | LDR - O363 | Equus sp. | femur, left | fragment | Lena Delta Region | Bykovsky Peninsula, Koryakinskoe L. | Sizintsev I. P. | 1988 | |
| 237 | LDR - O364 | Equus sp. | femur, left | fragment | Lena Delta Region | Bykovsky Peninsula, Koryakinskoe L. | Sizintsev I. P. | 1988 | juv. |
| 238 | LDR - O365 | Mammuthus primigenius | femur | fragment | Lena Delta Region | Bykovsky Peninsula, Koryakinskoe L. | Sizintsev I. P. | 1988 | juv. |
| 239 | LDR - O366 | Mammuthus primigenius | ulna | damaged | Lena Delta Region | Bykovsky Peninsula, Omulyakh Lagoon | Semivelichenk o V. A. | 2002 | juv. |
| 240 | LDR - O367 | Mammuthus primigenius | thorax vertebra | fragment | Lena Delta Region | Bykovsky P., Razdel'ny Cape | Yarlykov Yu. A. | 1988 | |
| 241 | LDR - O368 | Bison priscus | horn sheet | fragment | Lena Delta Region | Bykovsky Peninsula, Razdel'ny Cape | Yarlykov Yu. A. | 1988 | |
| 242 | LDR - O369 | Rangifer tarandus | mandible, left stem with dP2-dP4, M1-M3 | fragment | Lena Delta Region | Sardakh-Ary Isl. | Polyanskiy A. S. | 2000 | juv. |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 243 | LDR - O370 | Equus sp. | radius, left | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 244 | LDR - O371 | Equus sp. | pelvis, left part | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 245 | LDR - O372 | Equus sp. | tibia, left | | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 246 | LDR - O373 | Equus sp. | scapula, left | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 247 | LDR - O374 | Equus sp. | scapula, right | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | very fresh preservation |
| 248 | LDR - O375 | Rangifer tarandus | pelvis | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 249 | LDR - O376 | Bison priscus | lumbar vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 250 | LDR - O377 | Mammuthus primigenius | radius | fragment | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 2000 | |
| 251 | LDR - O378 | Bison priscus | cervical vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 2000 | |
| 252 | LDR - O379 | Bison priscus | cervical vertebra | damaged (3 pieces) | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 253 | LDR - O380 | Bison priscus | cervical vertebra | damaged (2 pieces) | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 254 | LDR - O381 | Bison priscus | cervical vertebra | damaged | Lena Delta Region | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 255 | LDR - O382 | Ursus arctos? | femur, right | damaged | Дельта р. Лена | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 256 | LDR - O383 | Equus sp. | Mt III, left | | Дельта р. Лена | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 257 | LDR - O384 | Equus sp. ? | sacrum | damaged | Дельта р. Лена | Kurungnakh-Sise Isl. | Gukov A. Yu. | 1998 | |
| 258 | LDR - O385 | Equus sp. | femur, left | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Rizhiy S. N. | 2004 | |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 259 | LDR - O386 | Bison priscus | small bone of carpus | damaged | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Rizhiy S. N. | 2004 | |
| 260 | LDR - O387 | Rangifer tarandus ? | atlas | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Rizhiy S. N. | 2004 | |
| 261 | LDR - O388 | Rangifer tarandus | ph I | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Natyaganchuk V. V. | 1989 | |
| 262 | LDR - O389 | Mammuthus primigenius | 1-st costa, right | fragment | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Natyaganchuk V. V. | 1989 | |
| 263 | LDR - O390 | Mammuthus primigenius | sternum | fragment | Lena Delta Region | Gusinaya Channel | Dormidontov V. M. | 1999 | |
| 264 | LDR - O391 | Mammuthus primigenius | costa | fragment | Lena Delta Region | Arynskaya Channel | Dormidontov V. M. | 1999 | |
| 265 | LDR - O392 | Mammuthus primigenius | vertebra | fragment | Lena Delta Region | Tumatskaya Channel | Musiy G. A. | 1999 | juv. |
| 266 | LDR - O393 | Mammuthus primigenius | vertebra | fragment | | Tit-Ary Isl. | Solov'ev S. A. | 1997 | juv. |
| 267 | LDR - O394 | Bison priscus | thorax | fragment | Lena Delta Region | Khardang-Sise Isl. | Gukov A. Yu. | 2000 | |
| 268 | LDR - O395 | Ovibos moschatus | cranium with horn cores | damaged | coast of Laptev Sea | Buor-Khaya Cape | Gukov A. Yu. | 1990 | female |
| 269 | LDR - O420 | Bison priscus | femur, left | distal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 270 | LDR - O422 | Bison priscus | ph II | | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 271 | LDR - O423 | Bison priscus | ph II | | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 272 | LDR - O424 | Bison priscus ? | metapodiale | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 273 | LDR - O449 | Bison priscus | atlas | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 274 | LDR - O450 | Bison priscus | cervical vertebra | | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 275 | LDR - O451 | Bison priscus | cervical vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 276 | LDR - O453 | Bison priscus | thorax vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 277 | LDR - O454 | Bison priscus | thorax vertebra | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | |
| 278 | LDR - O455 | Bison priscus | thorax vertebra | | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 279 | LDR - O456 | Bison priscus | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 280 | LDR - O457 | Bison priscus | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 281 | LDR - O458 | Bison priscus | lumbar vertebra | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 282 | LDR - O461 | Bison priscus | mandible, right stem | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 283 | LDR - O462 | Bison priscus | humerus, left | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 284 | LDR - O463 | Bison priscus | humerus, right | distal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 285 | LDR - O464 | Bison priscus | pelvis, left | fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 286 | LDR - O465 | Bison priscus | tibia, right | damaged | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |
| 287 | LDR - O466 | ? Bison priscus or Ovibos moschatus ? | tibia, left | distal fragment | Lena Delta Region | Bykovsky Peninsula, Mamontovaya Khayata | Sher A. V. | 2001 | DNA |

**Appendix 4-6:** Continuation

| No. | N samples | Taxon | Skeleton element | Preserva-tion | Region | Locality | Collector | Coll. Year | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 288 | LDR - P16 | Mammuthus primigenius | hair | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Sellyakhov F. V. | 2002 | |
| 289 | LDR - P229 | Mammuthus primigenius | hair | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Zimov'e R. | Yakshina I. A. | 2000 | |
| 290 | LDR -P71 | Coelodonta antiquitatis | hair | | Olenek Region | Taimylyr village | Krasovskaya T. D. | 2002 | AMS |
| 291 | LDR -P72 | Mammuthus primigenius | hair | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Eterikan R. | Sellyakhov F. V. | 2000 | AMS |
| 292 | LDR -P73 | Mammuthus primigenius | hair | | New Siberian Islands | Bol'shoy Lyakhovsky Isl., Shalourov Cape | Mikolauskas I. | 2001 | AMS |

# 5. Studies on Holocene permafrost in the Central Lena Delta

*Hanno Meyer, Alexander Dereviagin*

## 5.1 Introduction

The Holocene history of the Lena Delta is still insufficiently understood with regard to the development of channels and of permafrost when the delta reached its current position after the last marine transgression about 5 ka BP (Grigoriev, 1993). The development of Lena Delta in Holocene occurred under the complicated paleogeographical and geocryological conditions of climate warming, marine transgression, active tectonic movements and permafrost genesis including ice wedge and pingo formation. Several Radiocarbon dates are known from the first terrace of the Lena Delta with one exception all dated to the second half of the Holocene (Schwamborn et al. 2002, Pavlova et al. 1999).

During the numerous Russian-German expeditions in the frame of Lena projects, new information on geological-geomorphological structures and Holocene Delta history were obtained (Pavlova et al. 2002, Schwamborn et al. 2002, 2004). Based on this data, our studies of Holocene permafrost deposits in Lena Delta focus on two main aims:

- First to better understand the Holocene sedimentological and especially cryolithological history of the Delta.
- Second to use the isotopic composition of ground ice as palaeo-climate indicator in highest possible resolution.

The ground ice contains information of past atmospheric precipitation, which left an almost unaltered signal stored in the permafrost: its oxygen and hydrogen isotopic compositions. The isotopic composition of ice wedges i.e. can be related to winter precipitation and, thus, reflect winter temperatures of the time of ground ice formation. Therefore, a detailed radiocarbon-based study on the stable isotopic composition of Late Holocene ice wedges is supposed reveal the winter climate history of the last 4,000 to 5,000 years. This would be the first high-resolution (50 years) winter temperature record based on a real winter temperature proxy in areas, where in general in the Arctic only summer proxies (bioindicators) are available as climate indicators.

During the expedition 2005, the history of the first terrace was studied in the Central Lena Delta. The station on Samoylov Island served as a logistical base for a number of one-day motorboat trips to Holocene outcrops in the surroundings of the island. 10 outcrops were visited, described and sampled in detail between 11$^{th}$ August and 1$^{st}$ September 2005, among them outcrops on Samoylov Island, along Tumatskaya and Arynskaya Channel near De Longs memorial place, Sardakhskaya Channel near Sardakh Island, Kurungnakh Island and Olenyekskaya Channel (Figure 5-1). A second expedition is planned to complete the sampled sites for localities in the Olenyekskaya and Bykovskaya Channels in 2008 in the eastern and western part of Lena Delta.

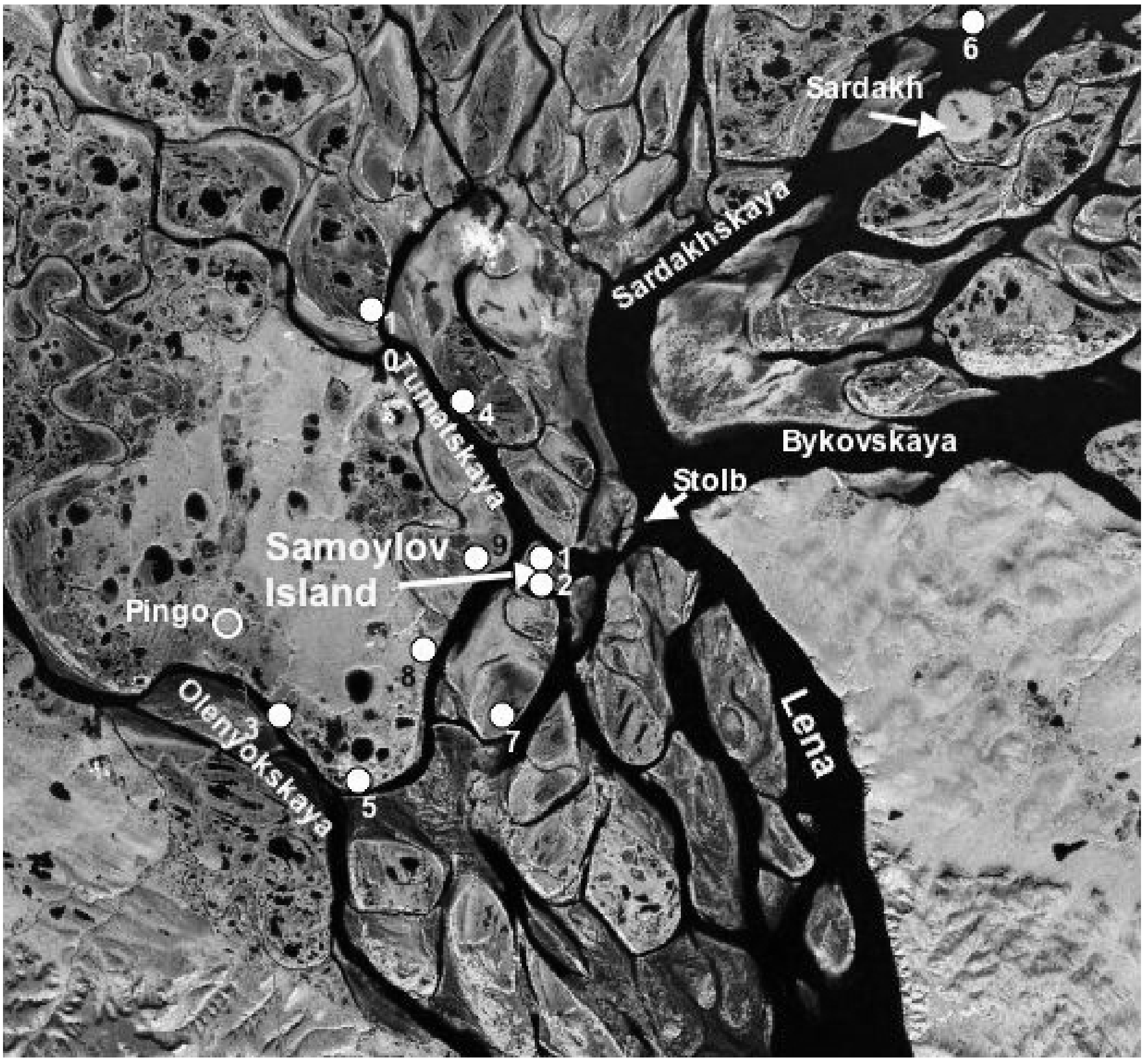


**Figure 5-1:** Landsat image of the Central Lena Delta including the sampled outcrops: (1) Samoylov Island site 1 (LD05-IW-1 and –2), (2) Samoylov Island site 2 (LD05-IW-3 and –4), (3) Olenyekskaya Channel site 1 (LD05-IW-5 and –6), (4) Tumatskaya Channel Site 1 (LD05-IW-7), (5) Olenyekskaya Channel site 2 (LD05-IW-8), (6) Sardakhskaya Channel (LD05-IW-9), (7) Arga Bylyr Areyta, (LD05-IW-10) (8) Kurungnakh site (LD05-IW-11), (9) Sasyl Ary site (LD05-IW-12), (10) Tumatskaya/Arynskaya Channel Site 2 (LD05-IW-13).

## 5.2 Outcrops

### 5.2.1 Outcrop 1

Samoylov Island, site 1, E facing cliff at the top of the first terrace,
two Holocene ice wedges (LD05-IW-1, LD05-IW-2)
Height: ca. 11 m above river level (a.r.l.)

The top part of the Samoylov Islands sedimentary sequence was sampled at this outcrop. The sediments include about 2.5 m of very peat-rich silty sands at the top with inclusions of thin sandy interbeds. Despite the relatively high mineral content, this unit is referred to as top peat horizon found in many places of the Island.

**Description LD05-IW-1:** Ice wedge LD05-IW-1 is cut perpendicularly to its frost cracking direction and reaches a width of 3.05 m at the top (max. width 3.5m). The depth of the active layer – a organic-rich sandy soil with a lot of mosses – reaches 0.45 m at this site. This ice wedge can be subdivided in a (1) about 1 m wide central part, a (2) 1 – 1.5 m lateral part and a (3) about 0.3 m wide part at both sides at the bottom of the ice wedge (Figure 5-2).

The central part of the ice wedge shows milky white to yellowish colour with mm to 0.5 cm wide single ice veins. This part is covered by a 0.8 m wide pocket of sediment, which was presumably caused by thermo-denudation due to standing or running water in the apex above the ice wedge. This assumption is likely because a nearby pond connected to the apex above ice wedge LD05-IW-1 is dry (drained by Lena River abrasion). At both sides of the central part of this ice wedge, ice of rather milky white to greyish colour is typical. At the upper right hand side of the ice wedge, a newly formed ice vein was observed in the still frozen part of the active (or transition) layer. At both sides of the bottom part, the ice wedge has brownish-coloured “shoulders”, which are connected to peat layers and ice belts in the adjacent sediment. This points to stable surface conditions at that time.

Subvertical structures are evident for the whole ice wedge. Since this ice wedge is very wide, a certain amount of time is necessary for its formation: assuming annual frost cracking (maximum hypothesis) and a maximum width of single ice veins of 0.5 cm, the minimum time interval spanned by LD05-IW-1 would be 600 years.

The sedimentary sequence of the outcrop includes very organic-rich silty sands with many ice-rich peat lenses, some with subvertically oriented roots. This is interpreted as a sign for autochthonous peat accumulation. Nonetheless, allochthonous peat accumulation cannot be ruled out. The cryostructure of the sediment is lens-like to reticulate, and some ice layers are found slightly bound upwards near ice wedges

**Sampling by chain saw:** Ice wedge: LD05-IW-1.1 to -1.5 (blocks), LD05-IW-1.6 to 1.28 (1.5 cm vertical slices in 10 cm intervals), LD05-IW-1.29 (contact ice wedge – sediment), LD05-IW-1.30 (recent ice vein); Sediment: LD05-S1 (near recent ice vein): 0.45 m, -S2: 1.0 m, -S3: 1.4 m below the surface.

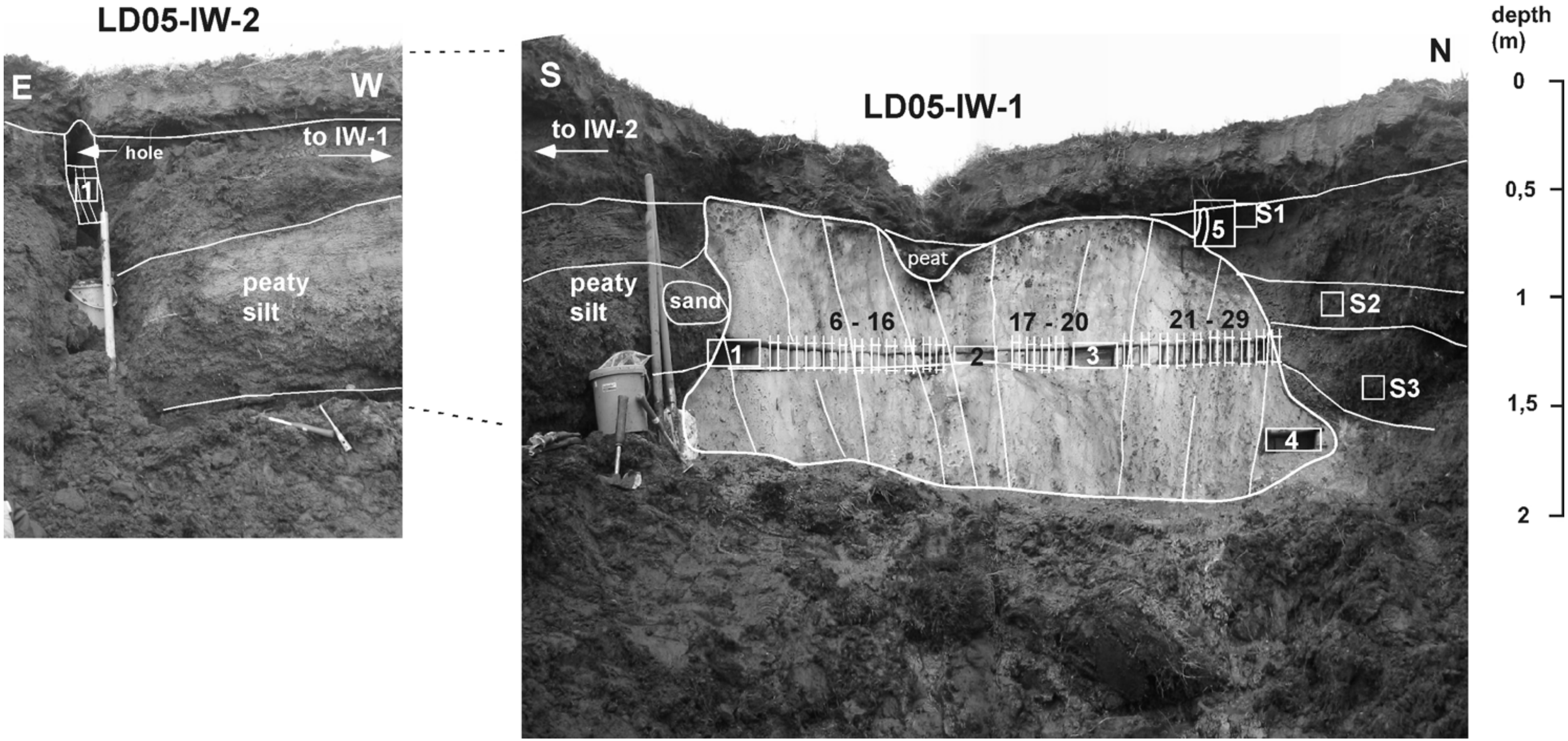


**Figure 5-2:** Sampling of outcrop 1 on Samoylov Island including LD05-IW-1 and LD05-IW-2

**Description LD05-IW-2:** Ice wedge LD05-IW-2 is located about 5 m to the SE of LD05-IW-1. It is about 0.25 m wide and cut in a right angle to its frost cracking direction. The ice wedge is related to a change in the hydrological regime, where an intrapolygonal pond was drained and the former rim of the polygon was cut by a new ice wedge generation. This ice wedge was certainly formed much later than LD05-IW-1 and most likely epigenetic to the surrounding sediments. Its upper 0.5 m have disappeared due to melting or sublimation of the ice (Figure 5-2).

**Sampling by chain saw:** Ice wedge: LD05-IW-2.1 (block)

### 5.2.2 Outcrop 2

Samoylov Island, site 2, E cliff, E facing cliff at the bottom of the first terrace, two Holocene ice wedges (LD05-IW-3, LD05-IW-4)

Height of the cliff: ca. 10 m a.r.l.; Sampling height: ca. 1 to 3.5 m a.r.l.

This outcrop comprises the whole sequence of the Samoylov Islands sediments (and ground ice). However, only the bottom part was sampled here. The sediments include about 4 m of peat at the top with inclusions of thin sand layers underlain by 2.5 m of yellowish-grey and organic-rich silty sands. Alternations of peat and sands containing ice wedges were observed between 3.5 m and 1.2 m a.r.l, These are interrupted by a prominent 0.15 m thick layer of allochthonous peat with large fragments of wood in a height of 2.5 m a.r.l., which was interpreted as “catastrophic horizon”. The lowermost meter is characterised by a yellowish sand layer with some organic or wood remains.

**Description LD05-IW-3:** Ice wedge LD05-IW-3 is milky-white as many Holocene ice wedges and reaches a width of 0.8 m at the top and a height of 1.5 m (Figure 5-3). A horizontal layer of most likely allochthonous peat with large wood fragments covers this ice wedge in height of 2.5 m a.r.l. Above this horizon the ice wedge LD05-IW-3 is molten and an ice wedge cast is found, at the right side laterally confined by ice layers bound upward near the former ice wedge. The wedge ice is characterised by very many gas bubbles mostly smaller than 0.5 mm, some vertically elongated and by some sand veins especially at the right hand side, where alternating ice-sand layers were observed.

**Sampling by chain saw:** Ice wedge LD05-IW-3.1 to 3.3 (blocks), height: 1.8 m a.r.l. Sediment: LD05-S4: 1.2 m, -S5: 1.7 m, -S6: 2.2 m, -S7: 2.7 m, -S8: 3.2 m a.r.l.

**Description LD05-IW-4:** This ice wedge is 3 to 5 cm wide and seems to be connected to the layer of peat at the top of this outcrop (Figure 5-3). Nonetheless, LD05-IW-4 is interrupted at the peat layer at 2.5 m a.r.l. Both above and below the “catastrophic horizon” ice wedge LD05-IW-4 is observed.

**Sampling by axe:** Ice wedge LD05-IW-4.1 to 4.5 (blocks)

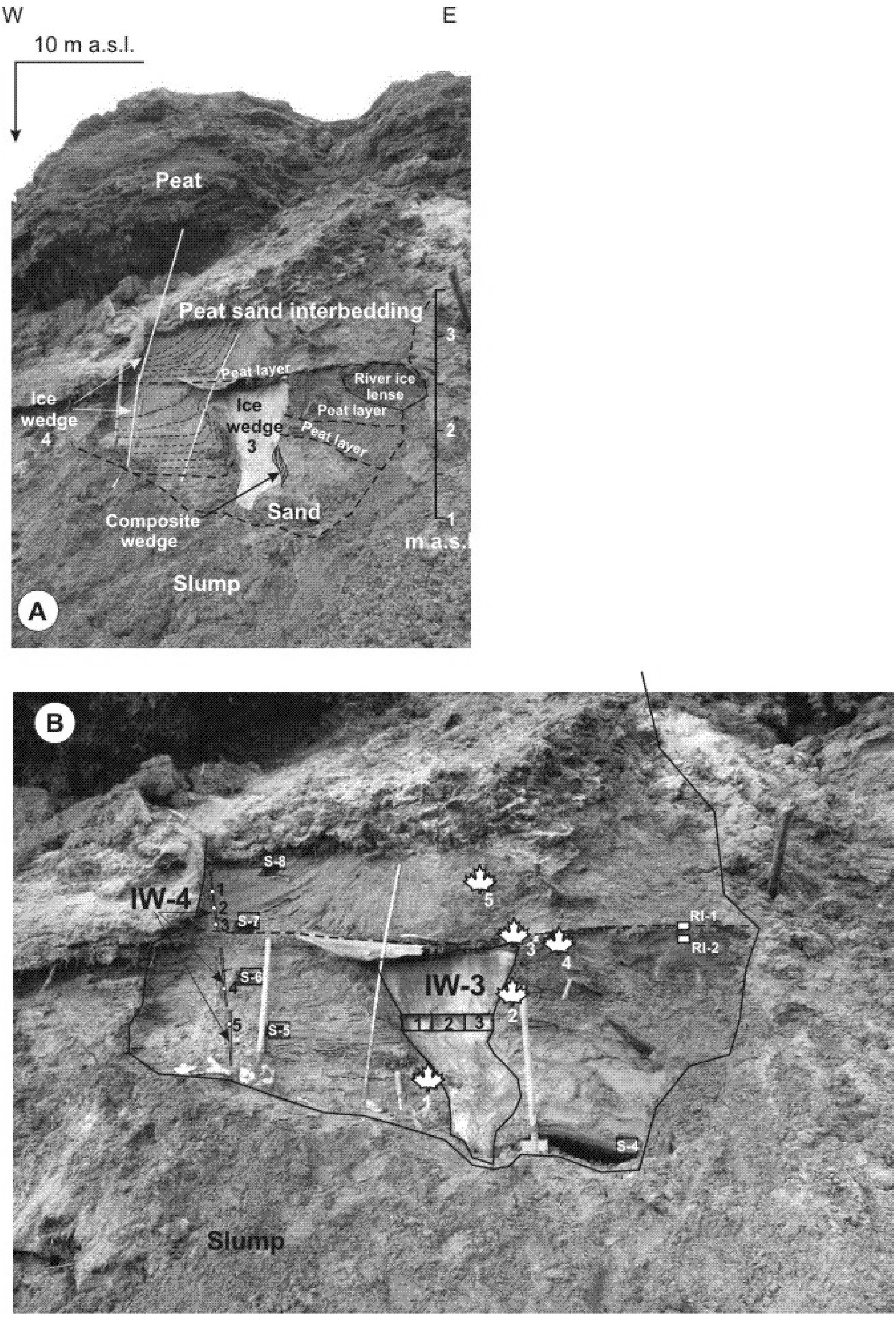


**Figure 5-3:** Sampling of outcrop 2 on Samoylov Island including LD05-IW-3 and LD05-IW-4

### 5.2.3 Geocryolithology on Samoylov Island: General impressions

Several generations of ice wedges were observed on Samoylov Island. Younger generations are associated to the peat horizon at the top of the section. Here, recent ice wedge growth occurs, evidently being are the youngest generation. The central part of ice wedge LD05-IW-1 is the youngest part in this ice wedge, with some features pointing to thermodenudation (water standing in the apex). After drainage of a nearby polygon centre, ice wedge LD05-IW-2 could form, maybe synchronously to the central part of LD05-IW-1. Towards the edge, ice wedge LD05-IW-1 gets increasingly older. The oldest section of the ice wedge is the brownish lower part.

At outcrop 2, older generations of ice wedges were found being subject to melting from the top (?) forming an ice wedge pseudomorph on top of LD05-IW-3. It is covered by a horizontal layer of most likely an allochthonous peat with large wood fragments, referred to as “catastrophic horizon" also found in other places of the Central Lena Delta. This peat layer is found at about 2.5 m a.r.l. and points to a flooding event of unknown age.

At the south coast of Samoylov Island, no ice wedges were found. Despite of that, traces of former ice wedges (such as wedge shaped holes sometimes several tens of metres in horizontal extension as well as palaeo frost cracks) indicate their former existence. Their disappearance is most likely related to sublimation of the ice and may point to the relative higher stability of the S cliff as compared the E and NE cliffs of the Island where thermo-erosion and –abrasion by Lena River are evident with large blocks fallen to the river or the much higher abundance of ice wedges.

### 5.2.4 Outcrop 3

Olenyekskaya Channel, site 1, SE facing cliff of the first terrace
Two Holocene ice wedges (LD05-IW-5 and IW-6)
Height of the cliff: ca. 11-12 m a.r.l.

**Description LD05-IW-5:** Ice wedge LD05-IW-5 is about 2.9 m wide. It is however not cut perpendicular to its growth direction, thus a smaller width of 1.8 m – 2 m seems more likely (Figure 5-4). In the height of 8 to 8.5 m a.r.l., two “shoulders” laterally confine the ice wedge; therefore above 8.5 m a.r.l., the width of the ice wedge narrows to about 1 m. The contents of sediment and organic matter in the ice wedge are relatively high, especially beneath the “shoulders” (Figure 5-4). The colour is milky-white to yellowish white as for many Holocene ice wedges rich in organic matter. The ice wedge IW-5 is embedded in dark brown to black peat with relatively low content of predominantly grey silty sediment with traces of clay and sand. The peat has been sampled in three different depths between 6.2 m and 8.0 m a.r.l.

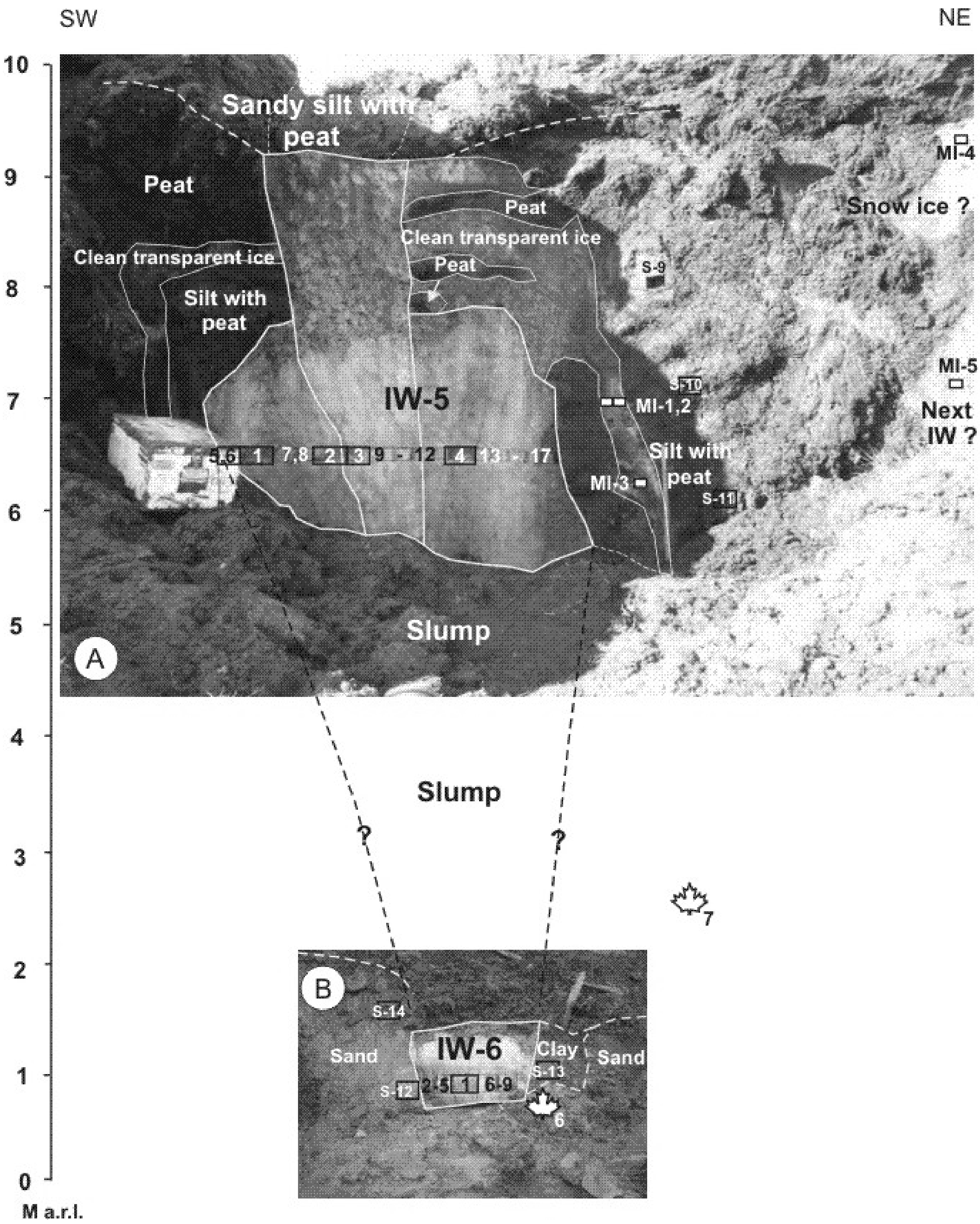


**Figure 5-4:** Sampling of outcrop 3 at Olenyekskaya Channel, site 1 including LD05-IW-5 and LD05-IW-6

Due to the high organic content, intrasedimental ice is very common such as lenses of pure structureless ice up to 1 m in length. A vertically oriented ice body (filling of a fissure?) has been sampled (LD05-MI-1 to MI-3) at the right side of LD05-IW-5.

**Sampling by chain saw:** Ice wedge LD05-IW-5.1 to 5.4 (blocks), LD05-IW-5.5 to 5.17 (1.5 cm vertical slices in 10 cm intervals), sampling height: 5.8 m a.r.l. Sediments: LD05-S9: 8.0 m, -S10: 7.1 m, -S11: 6.2 m a.r.l.

**Description LD05-IW-6:** Ice wedge LD05-IW-6 is situated about 5 m below IW-5 in a small outcrop near river level (Figure 5-4). It is about 0.9 m wide and about 1.1 m high and was sampled in a height of 0.3 m a.r.l., thus in the lowermost part of the first Lena terrace. It is assumed that this outcrop contains relatively old sediments and potentially old ice as well. However, the question if the outcrop 3 contains an especially old generation of ice wedges cannot be answered yet, since the top of the ice wedge IW-6 is buried under sediment debris. The contents of sediment and organic matter in the ice wedge are rather low and its colour is milky-white (Figure 5-4). Ice wedge IW-6 is laterally confined by brown to grey clay in the right side and by grey to brown silt in the left side of the ice wedge. Clay is very unusual in the Lena Delta, which is basically composed of sand and silt. Most likely a relatively deep lake with still water existed at this position permitting the deposition of clay.

**Sampling by chain saw:** Ice wedge LD05-IW-6.1 (block), LD05-IW-6.2 to 6.9(1.5 cm vertical slices in 10 cm intervals), sampling height: 0.3 m a.r.l. Sediments: LD05-S12: 0.4 m (silt), -S13: 0.6 m (clay), -S14: 1.5 m a.r.l (silt).

### 5.2.5 Outcrop 4

Tumatskaya Channel, SE facing cliff of the first terrace,
Holocene ice wedge (LD05-IW-7); sampling in three profiles
Height of the cliff: 8.5 m a.r.l.

**Description LD05-IW-7:** Ice wedge LD05-IW-7 is situated in a 8.5 m high cliff of the first Lena terrace. It was sampled in three different height levels between 7.5 and 2.7 m a.r.l. (Figure 5-5). The sedimentary sequence consists of peat with small wood fragments and organic-rich silt with lens-like reticulate cryostructure. At the top of the outcrop, the peat may reach a thickness of 3.5 m, thinning towards the ice wedge to about 1.5 m. The peat horizon is underlain by peaty silts and peaty sands. A 10 cm thick and most likely allochthonous peat layer containing large wood fragments was found in a height of about 2.9 m a.r.l. This peat corresponds most likely to the “catastrophic horizon” at Samoylov Island (outcrop 2). Since the ice wedge cuts this peat horizon, it must be younger than the peat (or *vice versa*, the peat is older than the ice wedge). The ice wedge LD05-IW-7 is milky-white and reaches a width of 1.4 m at the top of the outcrop. It is cut perpendicular to its growth direction and contains a lot of sediment inclusions and organic material such as lemming droppings. The diameter of the corresponding hexagonal low-centred polygons is 15 to 20 m. The upper two sampling profiles of ice wedge LD05-IW-7 belong to the same (N-S oriented) ice wedge, whereas the ice wedge of the lowermost profile (sample 7.31) has a NW-SE orientation.

**Sampling by chain saw:** Ice wedge LD05-IW-7; upper profile (height: 7.5 m a.r.l.) LD05-IW-7.1 (block), IW-7.2 to 7.17 (1.5 cm vertical slices in 10 cm intervals); middle profile (height: 5.2 m a.r.l.) LD05-IW-7.18 and 7.19 (blocks), IW-7.20 to 7.30 (10 cm intervals); lower profile (height: 2.7 m a.r.l.) LD05-IW-7.31 (block).

Sediments: LD05-S15: 7.9 m, -S16: 7.35 m, -S17: 6.9 m, -S18: 6.4m, -S19: 5.95 m, -S20: 5.25 m, -S21: 4.7 m, -S22: 4.1 m, -S23: 3.7, -S24: 3.2 m, -S25: 2.7 m

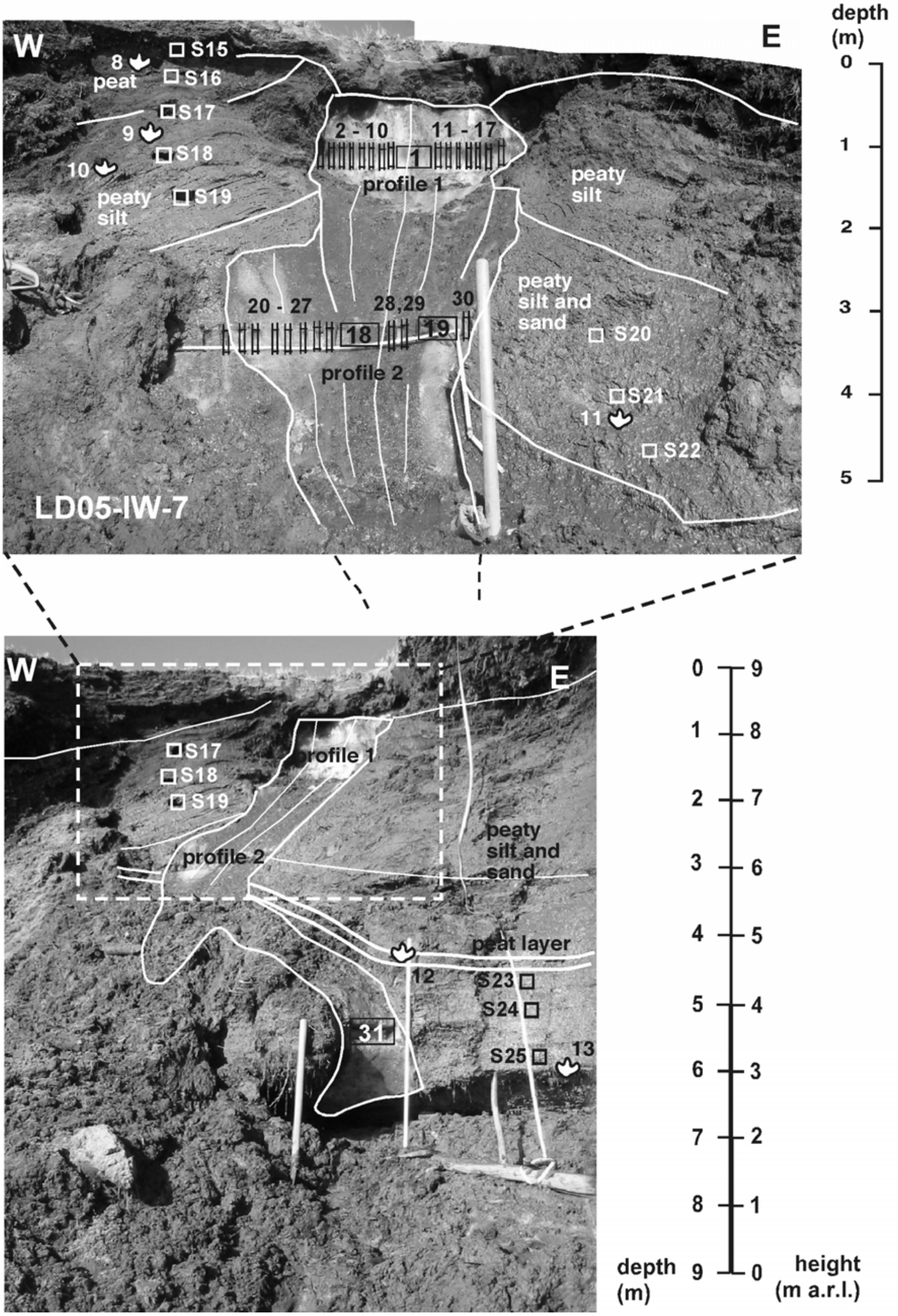


**Figure 5-5:** Sampling of outcrop 4, Tumatskaya Channel, site 1 including LD05-IW-7

### 5.2.6 Outcrop 5

Olenyekskaya Channel, S facing cliff of the first terrace,
Holocene ice wedge (LD05-IW-8)
Height of the cliff: 11 m a.r.l.

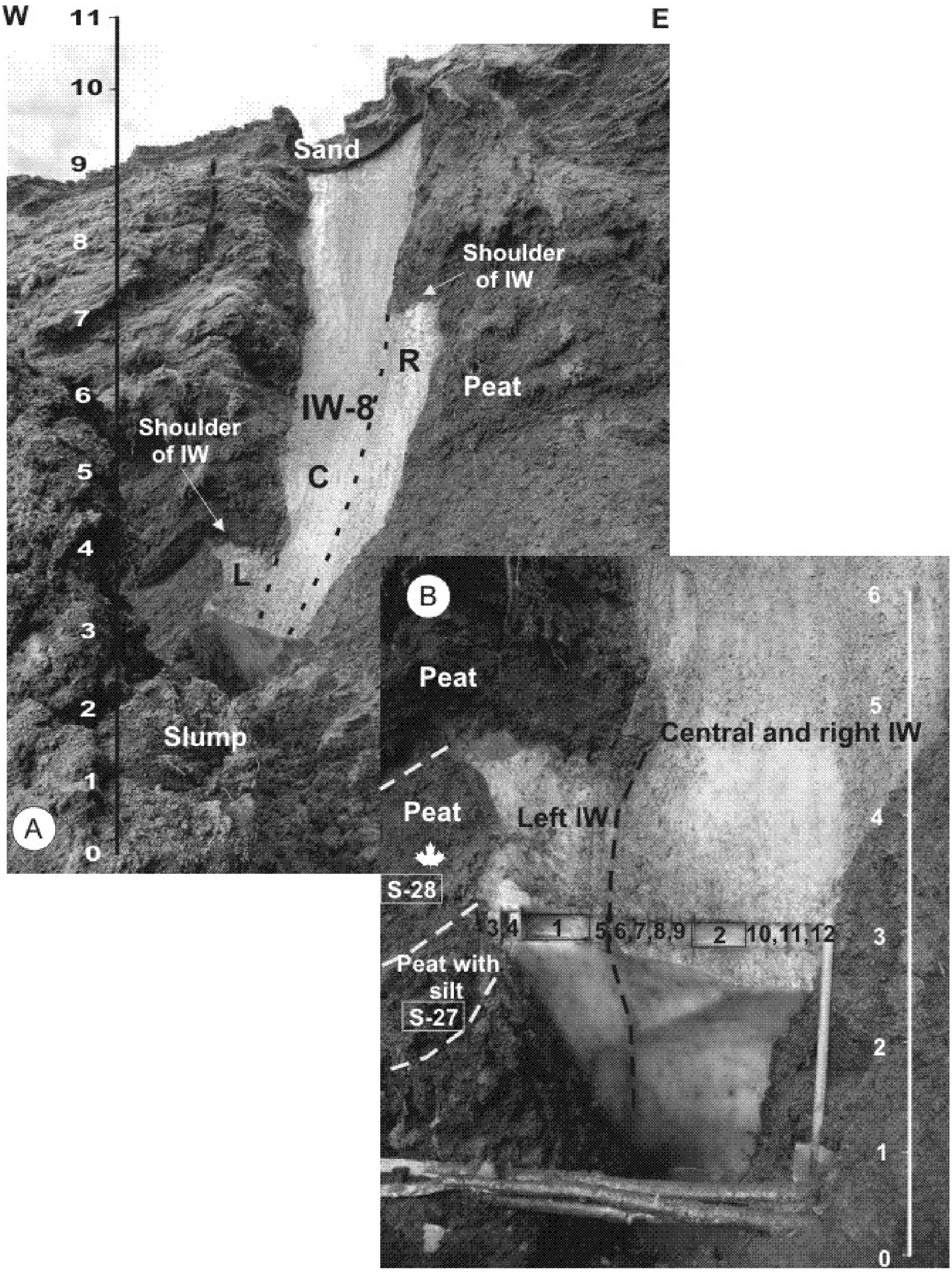


**Figure 5-6:** Sampling of outcrop 5 at Olenyekskaya Channel, site 2 including LD05-IW-8. A) general overview, B) sampling points. R –right side, L- left side, C-central part

Description LD05-IW-8: Ice wedge LD05-IW-8 was sampled in a 11 m high cliff of the first Lena terrace at Olenyekskaya Channel. It was sampled in a height of 2.5 m a.r.l. (Figure 5-6). The sedimentary sequence consists of 11 meters of peat with numerous roots and few wood remains, which was interpreted as a mostly likely autochthonous (?) peat. In the bottom part of the section the peat includes lenses and thin layers of gray with lens-like reticulate cryostructure. The ice wedge IW-8 is milky-white and reaches a maximum width of about 2.2 m at the top of the outcrop as well as 1.3 m width at the sampling profile. It is cut perpendicular to its growth direction and contains quite some organic and mineral inclusions. LD05-IW-8 is a high and narrow ice wedge with two well-pronounced shoulders in respective heights of 3.5 m and 6.5 m a.r.l. The ice wedge is subdivided in three vertical sections, which are related to the horizontal shoulders: the central part (C), the right part (R) and the left part (L). These parts indicate different stages of ice wedge formation. Part L is an oldest part, part C the youngest one. The height of LD05-IW-8 is more than 10 m, the horizontal extension varies from 1 to 2.2 m. It was sampled in a height of 2.5 m. The ice of ice wedge is clean, milky-white and very porous due to the inclusion of many air bubbles (1-3 mm in diameter).

**Sampling by chain saw:** Ice wedge LD05-IW-8.

LD05-IW-8.1 (block, part L), IW-8.2 (block, part C or R), IW-8.3 to 8.12 (1.5 cm vertical slices in 10 cm intervals)

Sediments: LD05-S26: 3.5 m, -S27: 1.5 m.

### 5.2.7 Outcrop 6

Gogolevsky Island, Sardakhskaya Channel, S facing cliff of the first terrace, Holocene ice wedge (LD05-IW-9)
Height of the cliff: 7-8 m a.r.l.

**Description LD05-IW-9:** The cliff of the first Lena terrace is at this position 7 to 8 m high and situated on Gogolevsky Island, Sardakhskaya Channel. The sedimentological profile consists of a thick peat horizon with sandy interbeds (Figure 5-7). In the upper part of the section, the peat is relatively sandy, however sedimentological differences are rather gradual. The cryogenic structure is massive and sometimes basal. LD05-IW-9 consists of two generations of ice wedges: a thinner (1.1 m) upper ice wedge (younger ice wedge) and a thicker (older) ice wedge at the bottom, whose width can only be estimated (to about 3 m). The ice wedge system is characterised by a horizontal shoulder separating two ice facies. Ice of the upper ice wedge is dirty and grey with numerous mineral and organic inclusions. Ice of older part (under the shoulders) is milky and white, with relatively large (1-2 mm) bubbles of air and mineral inclusions (mostly sand) as well as organic remains. LD05-IW-9 was sampled in a height of 4.2 m a.r.l. At this position, the total width of the ice wedge is 2.3 m. Samples LD05-IW-9.6 to –9.14 and –9.2 are from the central part of the ice wedge system. The corresponding ice wedge polygons are degraded low centre polygons 15 m in diameter with drained intrapolygonal ponds and very wide polygon walls, which are subject sometimes to secondary cracking (at a right angle to the original frost cracking activity). Some high-

centred polygons of smaller diameter (8-10 m) are found nearby. This points to a change in the original hydrological system.
The bottom part of ice wedge has been molten due to thermokarst processes and a large ice cave with an underground lake was formed. The underground lake water as well as snow remnant near the ice wedge shoulder were both sampled.

**Sampling by chain saw:** Ice wedge LD05-IW-9.

LD05-IW-9.1 (block, left part), IW-9.2 (block, central part), IW-9.3 to 9.19 (1.5 cm vertical slices in 10 cm intervals). Sediments: LD05-S28: 5.9 m, -S29: 5.5 m, -S30: 5.05 m, -S31: 4.25 m, -S32: 3.6 m a.r.l.

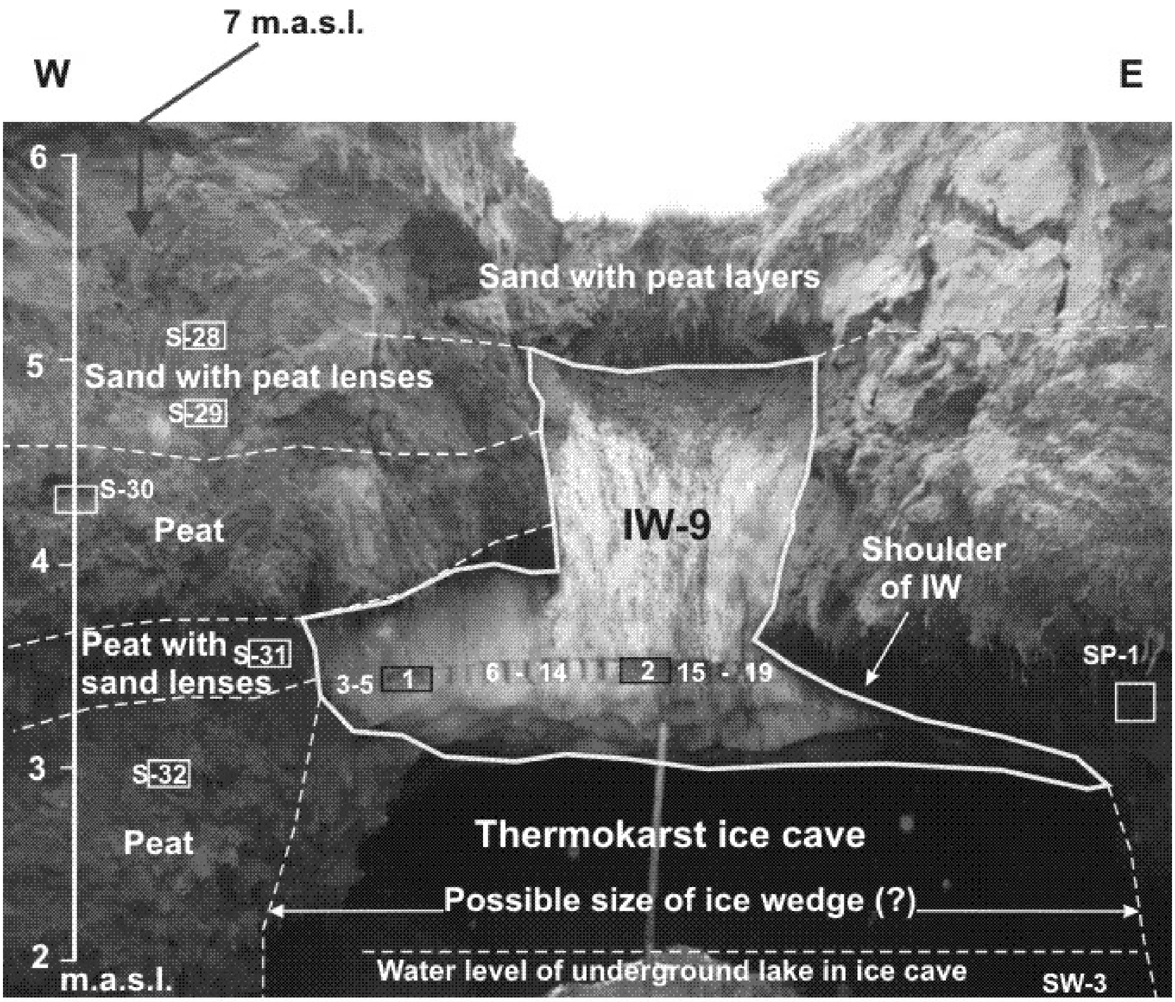


**Figure 5-7:** Sampling of outcrop 6, Sardakhskaya Channel including LD05-IW-9

### 5.2.8 Outcrop 7

Sasyl-Ary Island, Olenyekskaya Channel,
E facing cliff of the first terrace, Holocene ice wedge (LD05-IW-10)
Height of the cliff: 12 m a.r.l.

**Description LD05-IW-10:** Ice wedge LD05-IW-10 is situated at a 12 m high cliff of the first terrace at Sasyl-Ary Island, Olenyekskaya Channel (Figure 5-8). The geological profile is similar to outcrop 1 of Samoylov Island and consists of four main horizons all slightly bound upward near the ice wedge: (1) sand with ripple and cross-bedding structures with a few large gravel fragments in the bottom part of profile (0 - 4 m a.r.l.); (2) an allochthonous peat layer (“catastrophic horizon”) with large pieces of wood (4.0 - 4.5 m), (3) peat with sand layers and lenses. In the bottom part of this layer, sand, silty sand with peat inclusions) (4.5 - 7 m a.r.l.); and a (4) thick peat horizon (7 - 11.5 m a.r.l.) with numerous large wood remains at the top of the outcrop, which let us believe that the peat was deposited (at least partly) by river action. The cryogenic texture is mostly massive. The active layer is about 0.5 to 0.6 m thick.

Ice wedge LD05-IW-10 is milky-white and most likely the intersection of two smaller ice wedges, because two main orientations of frost cracking structures were observed. The width of LD05-IW-10 is between1.4-2.0 m (1.4 m at the sampling transsect). The middle and bottom parts of LD05-IW-10 are wider than the topmost part. Ice wedge LD05-IW-10 has no well-pronounced horizontal shoulders.

**Sampling by chain saw:** Ice wedge LD05-IW-10.

LD05-IW-10.1 (block, 8.9 m a.r.l.), IW-10.2 (block, 6.4 m a.r.l.), IW-10.3 to 10.14 (1.5 cm vertical slices in 10 cm intervals; 8.9 m a.r.l.). Sediments: LD05-S33: 8.5 m, -S34: 4.0 m a.r.l.

### 5.2.9 Outcrop 8

Kurungnakh Island, Olenyekskaya Channel, E facing cliff, Holocene cover (bylar) of third Lena River terrace (Ice Complex), Holocene ice wedge (LD05-IW-11)

Height of the cliff: ca. 25 m a.r.l.

**Description LD05-IW-11:** Ice wedge LD05-IW-11 was sampled in a 25 m high cliff of the third Lena river terrace at Kurungnakh Island, right coast of Olenyekskaya Channel (Figure 5-9). It is located at the top of the Ice Complex between two large Late Pleistocene ice wedges and is attributed to the Holocene cover on top of the Ice Complex (bylar). It has certainly never been reached by flooding, but may not properly represent the conditions of the first terrace or might have been formed earlier.

The geological profile consists of three units: (1) ice-rich greyish silty sand (alevrit) with ice bands as well as peat lenses or pockets in the bottom part (typical Ice Complex deposits), overlain by (2) similar deposits without ice bands. Both units are dominated by lens-like reticulate cryostructure. The topmost unit (3) consists of silty sands with few peat inclusions overlain by peat with silty sands dominating the upper 2-3 m of the profile (possibly deposits of small thermokarst lakes and ponds – so called “bylar”). The thickness of active layer is about 0.3-0.4 m.

LD05-IW-11 is more than 6 m high with two well-pronounced shoulders. In the upper part it is about 2.5 m wide narrowing to about 0.3 m at the 6 m depth. The orientation is approximately 45° to the cliff, nonetheless it was sampled perpendicular to the growth direction. Subvertical structures such as up to 4 mm wide single ice veins are evident. The ice of ice wedge LD05-IW-11 is clean and white and contains very few mineral and many organic particles as well as many gas bubbles This contrasts with the adjacent Late Pleistocene ice wedges, which are much dirtier due to mineral inclusions.

**Sampling by chain saw:** Ice wedge: LD05-IW-11.1 (block, upper profile), IW-11.2 (block, lower profile), LD05-IW-11.3 to 11.13 (1.5 cm vertical slices in 10 cm intervals, upper profile). Lower profile: 4.8 m, Upper profile: 3.0 m below the surface.

Sediment: LD05-S35: 2.0 m, -S36: 2.8 m, -S37: 1.2 m, -S38: 3.6 m below the surface.

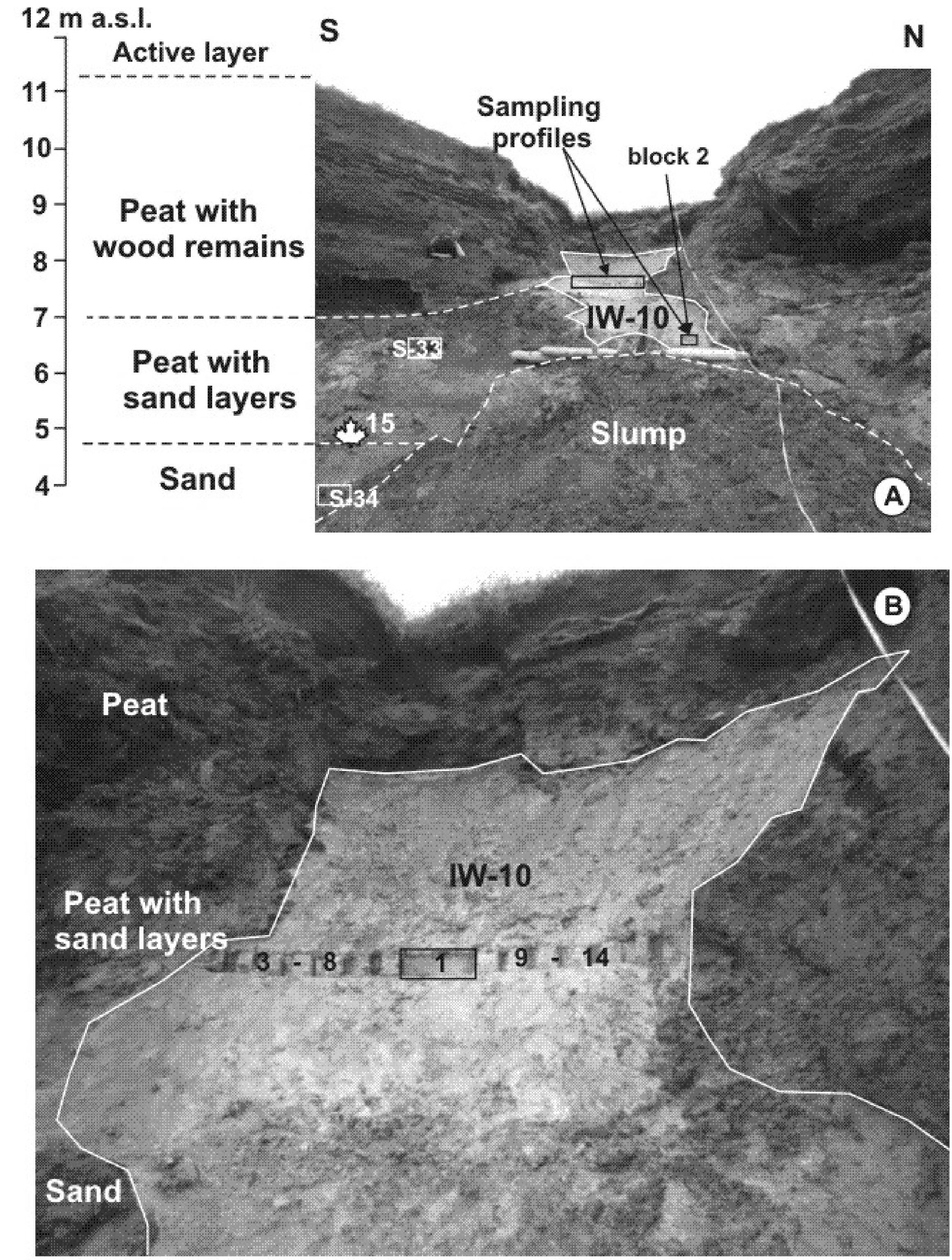


**Figure 5-8:** Sampling of outcrop 7 at Sasyl-Ary Island, Olenyekskaya Channel including LD05-IW-10. A general overview, B) sampling points

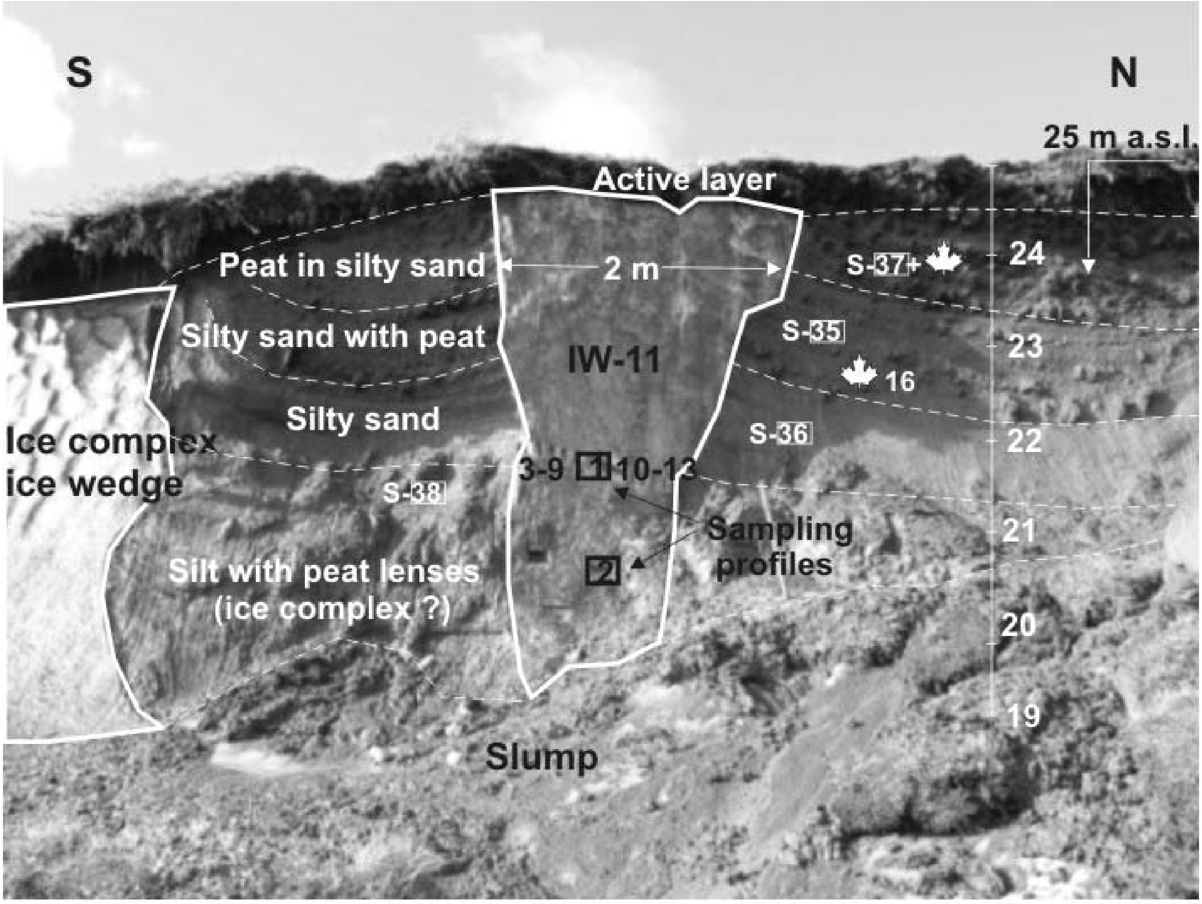


**Figure 5-9:** Sampling of outcrop 8, Kurungnakh Island including LD05-IW-11

### 5.2.10 Outcrop 9

Arga Bylyr Areita, W of Samoylov Island, E facing cliff at the top of the first terrace,
Holocene ice wedge (LD05-IW-12)
Height: 7 m above river level (a.r.l.)

**Description LD05-IW-12:** Ice wedge LD05-IW-12 is a Holocene ice wedge of the first terrace, most likely inactive (Figure 5-10). At the surface on top of the ice wedge, a small depression points to the possibility of degradation by flooding or standing water. It is cut perpendicularly to its frost cracking direction and reaches a maximum width of 2.4 m. The depth of the active layer, a sandy soil with a lot of organic material, reaches 0.4 m at this site. Between the active layer and the top of the ice wedge, about 1 m of peaty sands are found, containing large ice lenses of up to 1.6 m in length and 0.6 m in height (one of these has the form of an “eye of the tiger”). The ice wedge can be subdivided in a (1) about 0.3 m wide central part proceeding to the overlying peaty sand horizon, where three single ice veins are buried by peaty sands; (2) two 1 m wide lateral parts. The ice wedge is milky-white, slightly yellowish, and subvertical structures are easily recognisable. The sampling transect is 3 m below the surface, thus, 4 m above river level. At both sides, the ice wedge is confined by structureless massive ice, which may be clear transparent, milky-white or turbid yellowish-brown. These ice lenses/ massive ice bodies were sampled as MI (massive ice) -6 to MI-12. To summarise, ice wedge LD05-IW-

12 is an example for the Holocene first Lena terrace below the maximum flooding level.

**Sampling by chain saw:** Ice wedge: LD05-IW-12.1 (block), IW-12.2 (block), LD05-IW-12.3 to 12.24 (1.5 cm vertical slices in 10 cm intervals), LD05-IW-1.25 to –IW-27 (buried ice veins); Massive ice: MI-6 to –12. Sediment: LD05-S39: 1.1 m, -S40: 1.55 m, -S41: 2.1 m, -S41: 2.6 m below the surface.

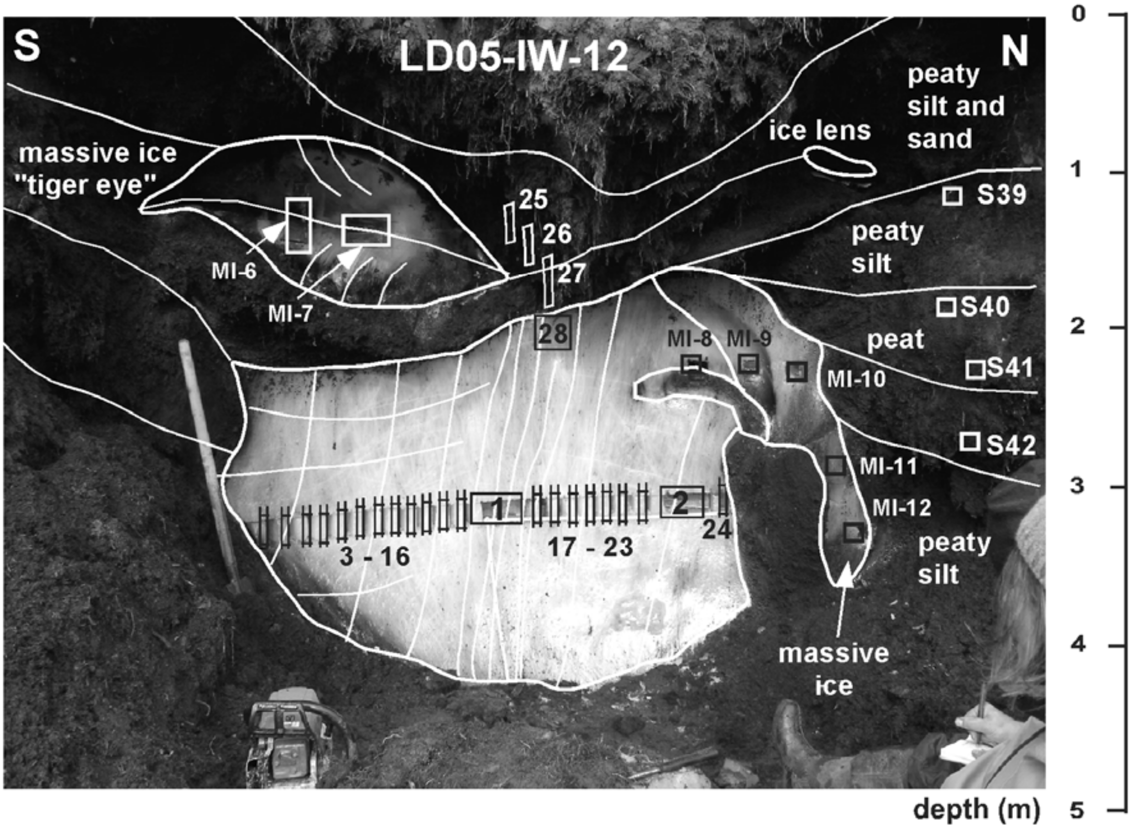


**Figure 5-10:** Sampling of outcrop 9, Arga Bylyr Areita Island including LD05-IW-12

### 5.2.11 Outcrop 10

Tumatskaya Channel near Amerika Khaya (DeLongs memorial place), SE facing cliff at the top of the first terrace,
Holocene ice wedge (LD05-IW-13)
Height: 8-9 m (a.r.l.)

**Description LD05-IW-13:** Ice wedge LD05-IW-13 is the northernmost outcrop of this sampling campaign and situated at Tumatskaya Channel near Amerika Khaya (Figure 5-11). The sedimentological profile consists of three main horizons: two peat horizons and an interbedding organic-rich sand horizon. The upper peat reaches a thickness of 2.5 – 3.5 m, contains many roots and sphagnum fragments, no wood remains and is, thus considered as autochthonous. The sandy horizon contains peat fragments and reaches a thickness of between 0.5 m and 1.5 m (near the ice wedge).

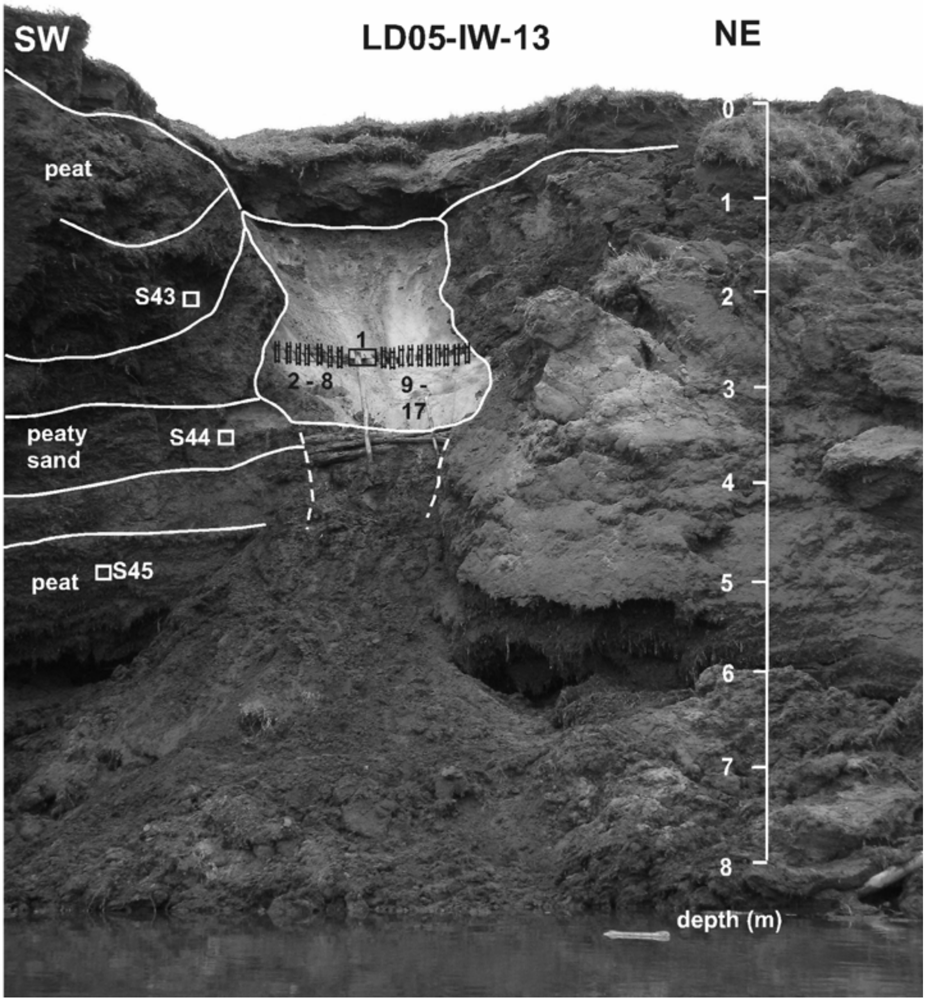


**Figure 5-11:** Sampling of outcrop 10, Tumatskaya Channel including LD05-IW-13.

The lower peat is about 4 m thick, black to reddish-brown, contains few roots and no wood remains and is assumed to be mostly autochthonous. Active layer thickness is 0.5 – 0.6 m. The outcrop 10 is comparable to outcrops 2 and 4. Ice wedge LD05-IW-13 is milky white to brownish, contains a lot of mineral particles (basically sand) and some organic matter. It is 1.75 m wide at the sampling transect and was sampled 3.0 m below the surface. Since the sampling was carried out at high level of Lena River, the height of the profile rather underestimated.

**Sampling by chain saw:** Ice wedge: LD05-IW-13.1 (block), LD05-IW-13.2 to 13.17 (1.5 cm vertical slices in 10 cm intervals), Sediment: LD05-S43: 2.6 m, -S42: 3.9 m, -S44: 5.7 m below the surface.

### 5.2.12 Pingo at Olenyekskaya Channel

**Description of the pingo:** A big pingo was found in a huge alas (thermokarst) depression at Kurungnakh Island, right coast of the Olenyekskaya Channel near outcrop 3 (Figure 5-12). The diameter of the alas depression is about 800-1000 m, which formed in ice-rich deposits of the Late Pleistocene ice complex. The net of polygons (15-25 m in diameter) characterise the floor of alas. A small lake is located at the distance of about 300-400 m from the pingo. The pingo is about 30 meters high and about 150 meters in diameter. The slopes are about 20-25° and have a rich vegetation cover of small (50 cm high) shrubs (Salix). The top of pingo is destroyed by a small thermokarst depression (4x20 m) forming a plateau-like saddle and five more elevated areas (like small domes). The north side shows signs of nival processes.

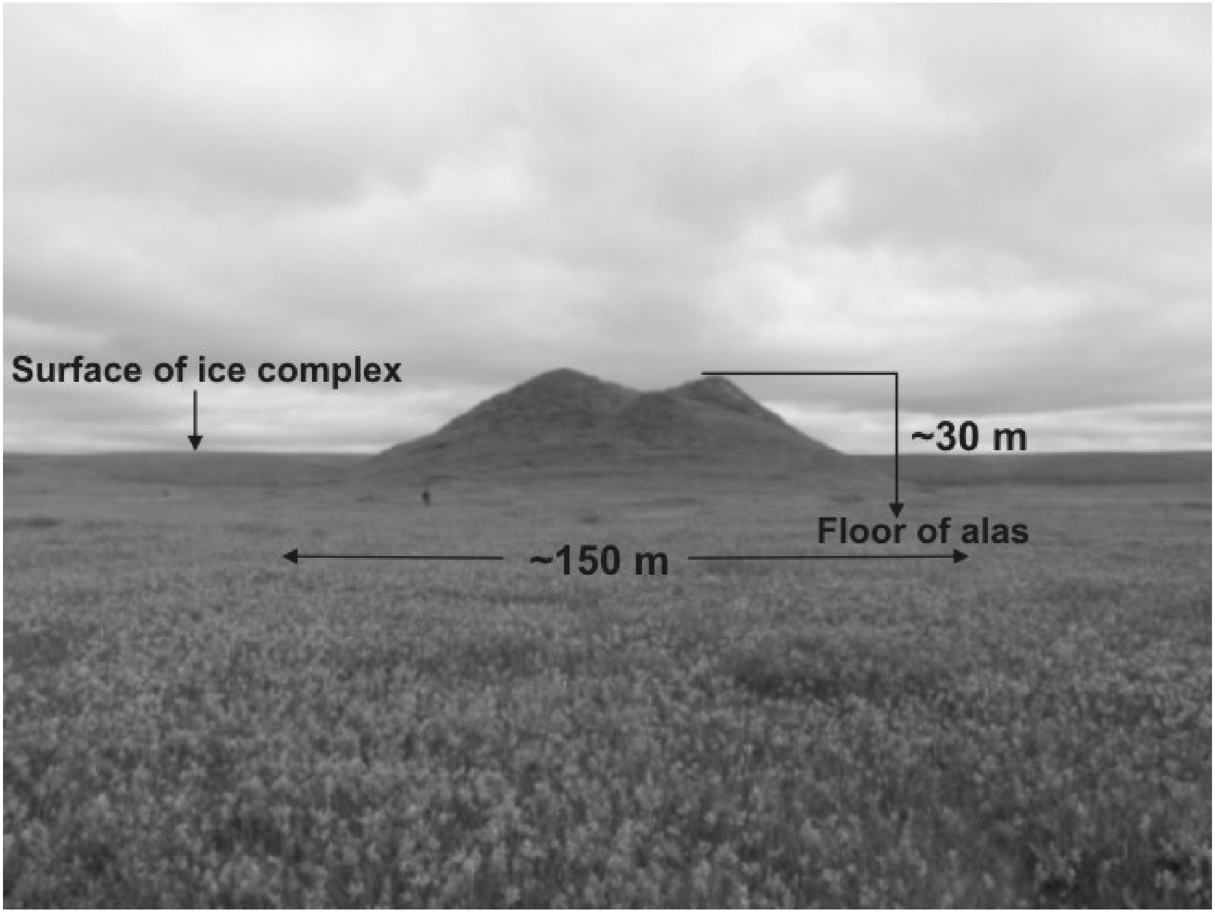


**Figure 5-12:** Setting of Pingo at Kurungnakh Island, right coast of Olenyekskaya Channel.

### 5.2.13 Summary

(1) Studying the outcrops of the first terrace in the Central Lena Delta gave new insight to the understanding of the genesis of this terrace and several new questions arose. All studied sections with ice wedges are characterised by peat horizons of different thicknesses varying between 3 m and more than 10 m. There are sections composed of organic-rich sand without covering peat horizon, which lack of ice wedges. These flood plain deposits were not tackled during this sampling campaign.

(2) It is a key question, whether the peat horizons in the sediment profiles are allochthonous (deposited by fluvial processes) or autochthonous (growing on site). For instance, larger wood fragments were certainly deposited by river activity and used as indicator for allochthonous peat deposition. The peat cover is mostly underlain by organic-rich sands. It can be assumed that main ice wedge growth started after the deposition of the (fluvial) sands, but this should be examined in further detail.

(3) Ice wedges are often characterised by shoulders, which could indicate stable surfaces (LD05-IW-8).

(4) A characteristic allochthonous peat horizon containing large pieces of wood was observed at different localities (Samoylov Island, Tumatskaya Channel) and in different height levels of the Central Lena Delta. This “catastrophic” horizon has most likely been deposited by river activity before ice wedge growth, since it is cut by ice wedges. The question is, if this deposition is a common phenomenon or a marker horizon for the Holocene Lena Delta. The “catastrophic peat” has been found between 1.8 m and 4 m a.r.l.

(5) There is an older generation of ice wedges underlying these deposits, which were found at different localities of the Central Lena Delta (Samoylov Island, Olenyekskaya Channel Tumatskaya Channel) combined with a different polygonal system. The age of this older polygonal system is unknown yet. It may occur in combination with (lacustrine?) clay (Olenyekskaya Channel), but also with peaty silts and sands (Samoylov Island).

(6) The ice wedges of the first terrace are easy to recognise because of their milky-white appearance and relatively high contents of organic matter. Since the organic matter in ice wedges can be dated by Radiocarbon, this allows us to directly date discrete pieces of ice. However, since organic matter within the ice may be derived from allochthonous or autochthonous peat, a careful selection of the samples to be dated is a prerequisite for a successful application of the $^{14}C$ dating method.

(7) Several signs of degradation of Holocene ice wedges systems were observed during our studies. This includes thermokarst processes e. g. by water standing above the ice wedges, thermoabrasion forming deep gullies, but also changes in the hydrological regime leading to the formation of high-centre polygons and secondary ice wedge growth.

(8) All samples taken during the field campaign LD05 including ice and water samples, sediment samples and samples of organic matter and plant are summarised in Table appendix 5-1, all sediment samples including the ice contents determined in the field can be found in Table appendix 5-2, all water samples with respective hydrochemical data (pH, conductivity) are given in Table appendix 5-3.

## 5.3 Studies on recent cryogenesis on Samoylov Island

The main aim of studying recent cryogenesis processes is to establish a stable isotope thermometer for ice wedges. The recent ice veins are attributed to the discrete year of their formation by means of tracer experiments. A tracer (coloured lycopodium spores) is applied to a polygon with recent cryogenesis, which allows identifying all types of ground ice, which were formed in the considered year.

Studies on recent ice wedge growth were continued for a polygon at the 1st Lena River terrace of Samoylov Island. For a detailed description of the site and the experimental set-up of the first three years, see Meyer (2003) and Meyer & Schneider (2004), Meyer and Kunitsky (2005). At the site, 10 different recent frost cracking experiments were installed. All experiments in 2005/2006 were equipped with voltage data loggers (type ESIS Minidan Volt) connected to breaking cables, which should log the moment of frost cracking.

Between 2004 and 2005, four out of ten experiments were successful and broken cables were observed. The following cables were broken: cables of experiment 2A-2B broke on 17$^{th}$ December, 2004; of experiment 6A-6B on 22 November, 2004 and of experiment 7A-7B cracked on 12 December, 2004. Unfortunately, loggers of experiments 4A-4B and 10A-10B failed. At experiment 5A-5B, about 10 small Cu wires were still in place, however, the experiment did not show any signs of cracking (changes of logger's voltage). At experiments 1A-1B, 3A-3B, 4A-4B, 5A-5B, 8A-8B and 9A-9B, the cables did not break. Poles to which the breaking cables are fixed were very loose, especially at those experiments, where the cables did not break,. Additionally, temperature loggers Temp-1 to Temp-4 were reinstalled to the experimental site to measure the thermal regime in the active layer on a polygon wall. Generally, the polygons were relatively wet with water standing in the polygon troughs (especially near experiment 8A-8B).

For the attribution of ice veins to the discrete year of their formation, tracer experiments were carried out. In late summer, 1 kg of **methyl orange** coloured *lycopodium* spores was applied to the polygon walls, especially to apexes above the frost crack to avoid drifting of spores by wind. In spring, when the snow cover melts, the spores should be washed into the crack. Since melt water freezes immediately, the spores are conserved in the newly formed ice vein, which can clearly be attributed to the year of its formation and then be sampled for stable isotopes.

## 5.4 References

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## 5.5 Appendices chapter 5

**Appendix 5-1:** Ice sample list

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 1 | LD05-99/01 | 12.08.2005 | RW | Samoylov - house | hand | bottle |
| 2 | LD05-IW-1.1 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | big frozen block in plastic pocket |
| 3 | LD05-IW-1.2 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | big frozen block in plastic pocket |
| 4 | LD05-IW-1.3 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | big frozen block in plastic pocket |
| 5 | LD05-IW-1.4 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | big frozen block in plastic pocket |
| 6 | LD05-IW-1.5 | 14.08.2005 | RIW | Samoylov - site 1 | chain saw | big frozen block in plastic pocket |
| 7 | LD05-IW-1.6 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 8 | LD05-IW-1.7 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 9 | LD05-IW-1.8 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 10 | LD05-IW-1.9 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 11 | LD05-IW-1.10 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 12 | LD05-IW-1.11 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 13 | LD05-IW-1.12 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 14 | LD05-IW-1.13 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 15 | LD05-IW-1.14 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 16 | LD05-IW-1.15 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 17 | LD05-IW-1.16 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 18 | LD05-IW-1.17 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 19 | LD05-IW-1.18 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 20 | LD05-IW-1.19 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 21 | LD05-IW-1.20 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 22 | LD05-IW-1.21 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 23 | LD05-IW-1.22 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 24 | LD05-IW-1.23 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 25 | LD05-IW-1.24 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 26 | LD05-IW-1.25 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 27 | LD05-IW-1.26 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 28 | LD05-IW-1.27 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 29 | LD05-IW-1.28 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 30 | LD05-IW-1.29 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket |
| 31 | LD05-IW-1.30 | 14.08.2005 | RIW | Samoylov - site 1 | chain saw | frozen slice in plastic pocket, bottle |
| 32 | LD05-S-1 | 14.08.2005 | SS | Samoylov - site 1 | chain saw | frozen block in plastic pocket |
| 33 | LD05-S-2 | 14.08.2005 | SS | Samoylov - site 1 | axe | frozen block in plastic pocket |
| 34 | LD05-S-3 | 14.08.2005 | SS | Samoylov - site 1 | chain saw | frozen block in plastic pocket |
| 35 | LD05-IW-2.1 | 14.08.2005 | IW | Samoylov - site 1 | chain saw | frozen block in plastic pocket |
| 36 | LD05-S-4 | 15.08.2005 | SS | Samoylov - site 2 | axe | frozen block in plastic pocket |
| 37 | LD05-S-5 | 15.08.2005 | SS | Samoylov - site 2 | chain saw | frozen block in plastic pocket |
| 38 | LD05-S-6 | 15.08.2005 | SS | Samoylov - site 2 | chain saw | frozen block in plastic pocket |
| 39 | LD05-S-7 | 15.08.2005 | SS | Samoylov - site 2 | chain saw | frozen block in plastic pocket |
| 40 | LD05-S-8 | 15.08.2005 | SS | Samoylov - site 2 | chain saw | frozen block in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 41 | LD05-14C-1 | 15.08.2005 | wood | Samoylov - site 2 | axe | plastic pocket |
| 42 | LD05-14C-2 | 15.08.2005 | wood | Samoylov - site 2 | axe | plastic pocket |
| 43 | LD05-14C-3 | 15.08.2005 | wood | Samoylov - site 2 | axe | plastic pocket |
| 44 | LD05-14C-4 | 15.08.2005 | peat | Samoylov - site 2 | hand | plastic pocket |
| 45 | LD05-14C-5 | 15.08.2005 | wood | Samoylov - site 2 | axe | plastic pocket |
| 46 | LD05-IW-3.1 | 15.08.2005 | IW | Samoylov - site 2 | chain saw | big frozen block in plastic pocket |
| 47 | LD05-IW-3.2 | 15.08.2005 | IW | Samoylov - site 2 | chain saw | big frozen block in plastic pocket |
| 48 | LD05-IW-3.3 | 15.08.2005 | IW | Samoylov - site 2 | chain saw | big frozen block in plastic pocket |
| 49 | LD05-IW-4.1 | 15.08.2005 | IW | Samoylov - site 2 | axe | bottle |
| 50 | LD05-IW-4.2 | 15.08.2005 | IW | Samoylov - site 2 | axe | bottle |
| 51 | LD05-IW-4.3 | 15.08.2005 | IW | Samoylov - site 2 | axe | bottle |
| 52 | LD05-IW-4.4 | 15.08.2005 | IW | Samoylov - site 2 | axe | bottle |
| 53 | LD05-IW-4.5 | 15.08.2005 | IW | Samoylov - site 2 | axe | bottle |
| 54 | LD05-TI-1 | 15.08.2005 | TI | Samoylov - site 2 | chain saw | bottle (=S7) |
| 55 | LD05-RI-1 | 15.08.2005 | RI | Samoylov - site 2 | axe | bottle |
| 56 | LD05-RI-2 | 15.08.2005 | RI | Samoylov - site 2 | axe | bottle |
| 57 | LD05-99/02 | 16.08.2005 | RW | Samoylov - house | hand | bottle |
| 58 | LD05-IW-5.1 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | big frozen block in plastic pocket |
| 59 | LD05-IW-5.2 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | big frozen block in plastic pocket |
| 60 | LD05-IW-5.3 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | big frozen block in plastic pocket |
| 61 | LD05-IW-5.4 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 62 | LD05-IW-5.5 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 63 | LD05-IW-5.6 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 64 | LD05-IW-5.7 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 65 | LD05-IW-5.8 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 66 | LD05-IW-5.9 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 67 | LD05-IW-5.10 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 68 | LD05-IW-5.11 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 69 | LD05-IW-5.12 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 70 | LD05-IW-5.13 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 71 | LD05-IW-5.14 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 72 | LD05-IW-5.15 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 73 | LD05-IW-5.16 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 74 | LD05-IW-5.17 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 75 | LD05-IW-6.1 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | big frozen block in plastic pocket |
| 76 | LD05-IW-6.2 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 77 | LD05-IW-6.3 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 78 | LD05-IW-6.4 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 79 | LD05-IW-6.5 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 80 | LD05-IW-6.6 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 81 | LD05-IW-6.7 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 82 | LD05-IW-6.8 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 83 | LD05-IW-6.9 | 17.08.2005 | IW | Olenyekskaya Channel - site 1 | chain saw | frozen slice in plastic pocket |
| 84 | LD05-S-9 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | chain saw | frozen block in plastic pocket |
| 85 | LD05-S-10 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | chain saw | frozen block in plastic pocket |
| 86 | LD05-S-11 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | chain saw | frozen block in plastic pocket |
| 87 | LD05-S-12 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | axe | frozen block in plastic pocket |
| 88 | LD05-S-13 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | axe | frozen block in plastic pocket |
| 89 | LD05-S-14 | 17.08.2005 | SS | Olenyekskaya Channel - site 1 | axe | frozen block in plastic pocket |
| 90 | LD05-MI-1 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | chain saw | bottle |
| 91 | LD05-MI-2 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | chain saw | bottle |
| 92 | LD05-MI-3 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | chain saw | bottle |
| 93 | LD05-MI-4 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | axe | bottle |
| 94 | LD05-MI-5 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | axe | bottle |
| 95 | LD05-14C-6 | 17.08.2005 | wood | Olenyekskaya Channel - site 1 | hand | plastic pocket |
| 96 | LD05-14C-7 | 17.08.2005 | wood | Olenyekskaya Channel - site 1 | hand | plastic pocket |
| 97 | LD05-SW-1 | 17.08.2005 | SW | Olenyekskaya Channel | hand | bottle |
| 98 | LD05-IW-7.1 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | big frozen block in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 99 | LD05-IW-7.2 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 100 | LD05-IW-7.3 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 101 | LD05-IW-7.4 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 102 | LD05-IW-7.5 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 103 | LD05-IW-7.6 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 104 | LD05-IW-7.7 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 105 | LD05-IW-7.8 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 106 | LD05-IW-7.9 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 107 | LD05-IW-7.10 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 108 | LD05-IW-7.11 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 109 | LD05-IW-7.12 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 110 | LD05-IW-7.13 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 111 | LD05-IW-7.14 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 112 | LD05-IW-7.15 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 113 | LD05-IW-7.16 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 114 | LD05-IW-7.17 | 18.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 115 | LD05-S-15 | 18.08.2005 | SS | Tumatskaya Channel site | chain saw | frozen block in plastic pocket |
| 116 | LD05-S-16 | 18.08.2005 | SS | Tumatskaya Channel site | chain saw | frozen block in plastic pocket |
| 117 | LD05-S-17 | 18.08.2005 | SS | Tumatskaya Channel site | chain saw | frozen block in plastic pocket |
| 118 | LD05-S-18 | 19.08.2005 | SS | Tumatskaya Channel site | chain saw | frozen block in plastic pocket |
| 119 | LD05-S-19 | 19.08.2005 | SS | Tumatskaya Channel site | chain saw | frozen block in plastic pocket |
| 120 | LD05-S-20 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |
| 121 | LD05-S-21 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |
| 122 | LD05-S-22 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |
| 123 | LD05-S-23 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |
| 124 | LD05-S-24 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |
| 125 | LD05-S-25 | 19.08.2005 | SS | Tumatskaya Channel site | axe | frozen block in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 126 | LD05-IW-7.18 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | big frozen block in plastic pocket |
| 127 | LD05-IW-7.19 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | big frozen block in plastic pocket |
| 128 | LD05-IW-7.20 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 129 | LD05-IW-7.21 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 130 | LD05-IW-7.22 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 131 | LD05-IW-7.23 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 132 | LD05-IW-7.24 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 133 | LD05-IW-7.25 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 134 | LD05-IW-7.26 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 135 | LD05-IW-7.27 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 136 | LD05-IW-7.28 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 137 | LD05-IW-7.29 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 138 | LD05-IW-7.30 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | frozen slice in plastic pocket |
| 139 | LD05-IW-7.31 | 19.08.2005 | IW | Tumatskaya Channel site | chain saw | big frozen block in plastic pocket |
| 140 | LD05-14C-8 | 19.08.2005 | peat | Tumatskaya Channel site | hand | plastic pocket |
| 141 | LD05-14C-9 | 19.08.2005 | peat | Tumatskaya Channel site | hand | plastic pocket |
| 142 | LD05-14C-10 | 19.08.2005 | wood | Tumatskaya Channel site | hand | plastic pocket |
| 143 | LD05-14C-11 | 19.08.2005 | wood | Tumatskaya Channel site | hand | plastic pocket |
| 144 | LD05-14C-12 | 19.08.2005 | wood | Tumatskaya Channel site | hand | plastic pocket |
| 145 | LD05-14C-13 | 19.08.2005 | peat | Tumatskaya Channel site | hand | plastic pocket |
| 146 | LD05-SW-2 | 19.08.2005 | SW | Tumatskaya Channel | hand | bottle |
| 147 | LD05-IW-8.1 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | big frozen block in plastic pocket |
| 148 | LD05-IW-8.2 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | big frozen block in plastic pocket |
| 149 | LD05-IW-8.3 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 150 | LD05-IW-8.4 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 151 | LD05-IW-8.5 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 152 | LD05-IW-8.6 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 153 | LD05-IW-8.7 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 154 | LD05-IW-8.8 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 155 | LD05-IW-8.9 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 156 | LD05-IW-8.10 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 157 | LD05-IW-8.11 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 158 | LD05-IW-8.12 | 20.08.2005 | IW | Olenyekskaya Channel - site 2 | chain saw | frozen slice in plastic pocket |
| 159 | LD05-S-26 | 20.08.2005 | SS | Olenyekskaya Channel - site 2 | axe | frozen block in plastic pocket |
| 160 | LD05-S-27 | 20.08.2005 | SS | Olenyekskaya Channel - site 2 | chain saw | frozen block in plastic pocket |
| 161 | LD05-99/03 | 21.08.2005 | RW | Samoylov | hand | bottle |
| 162 | LD05-IW-9.1 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | big frozen block in plastic pocket |
| 163 | LD05-IW-9.2 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | big frozen block in plastic pocket |
| 164 | LD05-IW-9.3 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 165 | LD05-IW-9.4 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 166 | LD05-IW-9.5 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 167 | LD05-IW-9.6 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 168 | LD05-IW-9.7 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 169 | LD05-IW-9.8 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 170 | LD05-IW-9.9 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 171 | LD05-IW-9.10 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 172 | LD05-IW-9.11 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 173 | LD05-IW-9.12 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 174 | LD05-IW-9.13 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 175 | LD05-IW-9.14 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 176 | LD05-IW-9.15 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 177 | LD05-IW-9.16 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 178 | LD05-IW-9.17 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 179 | LD05-IW-9.18 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 180 | LD05-IW-9.19 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 181 | LD05-IW-9.20 | 23.08.2005 | IW | Sardakhsky Channel site | chain saw | frozen slice in plastic pocket |
| 182 | LD05-S-28 | 23.08.2005 | SS | Sardakhsky Channel site | axe | frozen block in plastic pocket |
| 183 | LD05-S-29 | 23.08.2005 | SS | Sardakhsky Channel site | axe | frozen block in plastic pocket |
| 184 | LD05-S-30 | 23.08.2005 | SS | Sardakhsky Channel site | axe | frozen block in plastic pocket |
| 185 | LD05-S-31 | 23.08.2005 | SS | Sardakhsky Channel site | axe | frozen block in plastic pocket |
| 186 | LD05-S-32 | 23.08.2005 | SS | Sardakhsky Channel site | chain saw | frozen block in plastic pocket |
| 187 | LD05-SP-1 | 23.08.2005 | SP | Sardakhsky Channel site | chain saw | bottle |
| 188 | LD05-SW-3 | 23.08.2005 | SW | Sardakhsky Channel site | hand | bottle |
| 189 | LD05-SW-4 | 23.08.2005 | SW | Sardakhsky Channel | hand | bottle |
| 190 | LD05-14C-14 | 23.08.2005 | peat | Sardakhsky Channel site | hand | plastic pocket |
| 191 | LD05-RW-1 | 23.08.2005 | RW | Sardakhsky Channel site | hand | bottle |
| 192 | LD05-IW-10.1 | 25.08.2005 | IW | Sasyl Ary site | chain saw | big frozen block in plastic pocket |
| 193 | LD05-IW-10.2 | 25.08.2005 | IW | Sasyl Ary site | chain saw | big frozen block in plastic pocket |
| 194 | LD05-IW-10.3 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 195 | LD05-IW-10.4 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 196 | LD05-IW-10.5 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 197 | LD05-IW-10.6 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 198 | LD05-IW-10.7 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 199 | LD05-IW-10.8 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 200 | LD05-IW-10.9 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 201 | LD05-IW-10.10 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 202 | LD05-IW-10.11 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 203 | LD05-IW-10.12 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 204 | LD05-IW-10.13 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 205 | LD05-IW-10.14 | 25.08.2005 | IW | Sasyl Ary site | chain saw | frozen slice in plastic pocket |
| 206 | LD05-S-33 | 25.08.2005 | SS | Sasyl Ary site | axe | frozen block in plastic pocket |
| 207 | LD05-S-34 | 25.08.2005 | SS | Sasyl Ary site | axe | frozen block in plastic pocket |
| 208 | LD05-14C-15 | 25.08.2005 | wood | Sasyl Ary site | hand | plastic pocket |
| 209 | LD05-99/04 | 26.08.2005 | RW | Samoylov | hand | bottle |
| 210 | LD05-IW-11.1 | 27.08.2005 | IW | Kurungnakh site | chain saw | big frozen block in plastic pocket |
| 211 | LD05-IW-11.2 | 27.08.2005 | IW | Kurungnakh site | chain saw | big frozen block in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 212 | LD05-IW-11.3 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 213 | LD05-IW-11.4 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 214 | LD05-IW-11.5 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 215 | LD05-IW-11.6 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 216 | LD05-IW-11.7 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 217 | LD05-IW-11.8 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 218 | LD05-IW-11.9 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 219 | LD05-IW-11.10 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 220 | LD05-IW-11.11 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 221 | LD05-IW-11.12 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 222 | LD05-IW-11.13 | 27.08.2005 | IW | Kurungnakh site | chain saw | frozen slice in plastic pocket |
| 223 | LD05-S-35 | 27.08.2005 | SS | Kurungnakh site | axe | frozen block in plastic pocket |
| 224 | LD05-S-36 | 27.08.2005 | SS | Kurungnakh site | axe | frozen block in plastic pocket |
| 225 | LD05-S-37 | 27.08.2005 | SS | Kurungnakh site | axe | frozen block in plastic pocket |
| 226 | LD05-S-38 | 27.08.2005 | SS | Kurungnakh site | axe | frozen block in plastic pocket |
| 227 | LD05-14C-16 | 27.08.2005 | peat | Kurungnakh site | axe | frozen block in plastic pocket |
| 228 | LD05-99/05 | 28.08.2005 | RW | Samoylov | hand | bottle |
| 229 | LD05-SW-5 | 28.08.2005 | SW | Banja Lake, Samoylov | hand | bottle |
| 230 | LD05-SW-6 | 28.08.2005 | SW | Lena, Samoylov | hand | bottle |
| 231 | LD05-99/06 | 29.08.2005 | RW | Samoylov | hand | bottle |
| 232 | LD05-99/07 | 30.08.2005 | RW | Samoylov | hand | bottle |
| 233 | LD05-IW-12.1 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | big frozen block in plastic pocket |
| 234 | LD05-IW-12.2 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | big frozen block in plastic pocket |
| 235 | LD05-IW-12.3 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 236 | LD05-IW-12.4 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 237 | LD05-IW-12.5 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 238 | LD05-IW-12.6 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 239 | LD05-IW-12.7 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 240 | LD05-IW-12.8 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 241 | LD05-IW-12.9 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 242 | LD05-IW-12.10 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 243 | LD05-IW-12.11 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 244 | LD05-IW-12.12 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 245 | LD05-IW-12.13 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 246 | LD05-IW-12.14 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 247 | LD05-IW-12.15 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 248 | LD05-IW-12.16 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 249 | LD05-IW-12.17 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 250 | LD05-IW-12.18 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 251 | LD05-IW-12.19 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 252 | LD05-IW-12.20 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 253 | LD05-IW-12.21 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 254 | LD05-IW-12.22 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 255 | LD05-IW-12.23 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 256 | LD05-IW-12.24 | 31.08.2005 | IW | Arga Bylyr Areyta | chain saw | frozen slice in plastic pocket |
| 257 | LD05-IW-12.25 | 31.08.2005 | RIW | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 258 | LD05-IW-12.26 | 31.08.2005 | RIW | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 259 | LD05-IW-12.27 | 31.08.2005 | RIW | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 260 | LD05-IW-12.28 | 31.08.2005 | RIW | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 261 | LD05-MI-6 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 262 | LD05-MI-7 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 263 | LD05-MI-8 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | bottle |
| 264 | LD05-MI-9 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | bottle |
| 265 | LD05-MI-10 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | bottle |
| 266 | LD05-MI-11 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | bottle |
| 267 | LD05-MI-12 | 31.08.2005 | MI | Arga Bylyr Areyta | chain saw | bottle |
| 268 | LD05-S-39 | 31.08.2005 | SS | Arga Bylyr Areyta | axe | frozen block in plastic pocket |
| 269 | LD05-S-40 | 31.08.2005 | SS | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 270 | LD05-S-41 | 31.08.2005 | SS | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 271 | LD05-S-42 | 31.08.2005 | SS | Arga Bylyr Areyta | chain saw | frozen block in plastic pocket |
| 272 | LD05-14C-17 | 31.08.2005 | wood | Arga Bylyr Areyta | hand | frozen block in plastic pocket |
| 273 | LD05-14C-18 | 31.08.2005 | peat | Arga Bylyr Areyta | hand | frozen block in plastic pocket |
| 274 | LD05-IW-13.1 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | big frozen block in plastic pocket |
| 275 | LD05-IW-13.2 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 276 | LD05-IW-13.3 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 277 | LD05-IW-13.4 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 278 | LD05-IW-13.5 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 279 | LD05-IW-13.6 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 280 | LD05-IW-13.7 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 281 | LD05-IW-13.8 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 282 | LD05-IW-13.9 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 283 | LD05-IW-13.10 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 284 | LD05-IW-13.11 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 285 | LD05-IW-13.12 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 286 | LD05-IW-13.13 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 287 | LD05-IW-13.14 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 288 | LD05-IW-13.15 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |

**Appendix 5-1:** Continuation

| Nr | Sample | date | type | location | sampled by | packaging |
|---|---|---|---|---|---|---|
| 289 | LD05-IW-13.16 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 290 | LD05-IW-13.17 | 01.09.2005 | IW | Tumatskaya Channel - Site 2 | chain saw | frozen slice in plastic pocket |
| 291 | LD05-S-43 | 01.09.2005 | SS | Tumatskaya Channel - Site 2 | axe | frozen block in plastic pocket |
| 292 | LD05-S-44 | 01.09.2005 | SS | Tumatskaya Channel - Site 2 | axe | frozen block in plastic pocket |
| 293 | LD05-S-45 | 01.09.2005 | SS | Tumatskaya Channel - Site 2 | axe | frozen block in plastic pocket |
| 294 | LD05-SW-7 | 01.09.2005 | SW | Samoylov | hand | bottle |
| 295 | LD05-RIW-1 | 02.09.2005 | RIW | Samoylov | axe | frozen block in plastic pocket |
| 296 | LD05-d13C-1 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 297 | LD05-d13C-2 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 298 | LD05-d13C-3 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 299 | LD05-d13C-4 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 300 | LD05-d13C-5 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 301 | LD05-d13C-6 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 302 | LD05-d13C-7 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 303 | LD05-d13C-8 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 304 | LD05-d13C-9 | 02.09.2005 | plant | Samoylov | hand | pocket |
| 305 | LD05-d13C-10 | 02.09.2005 | plant | Samoylov | hand | pocket |

**Appendix 5-2:** List of sediment samples and ice content measurement

| Sample | Site | box no | inweight box [g] | box + sample (wet) [g] | box + sample (dry) [g] | Ice content [g] | Ice content (%) to dry weight | remarks |
|---|---|---|---|---|---|---|---|---|
| D05-S-1 | Samoylov - site 1 | - | - | - | - | | | |
| LD05-S-2 | Samoylov - site 1 | 397 | 22,2 | 54,9 | 29,9 | 25 | **325** | |
| LD05-S-3 | Samoylov - site 1 | 20 | 43,6 | 125,8 | 64,1 | 61,7 | **301** | |
| LD05-S-4 | Samoylov - site 2 | 354 | 22,3 | 69,6 | 51,7 | 17,9 | **61** | |
| LD05-S-5 | Samoylov - site 2 | B5 | 43,9 | 163,9 | 100,7 | 63,2 | **111** | |
| LD05-S-6 | Samoylov - site 2 | 1 | 43,6 | 193,8 | 128,6 | 65,2 | **77** | |
| LD05-S-7 | Samoylov - site 2 | 14 | 44,1 | 156 | 88,1 | 67,9 | **154** | |
| LD05-S-8 | Samoylov - site 2 | 22 | 44,9 | 160,6 | 88,2 | 72,4 | **167** | |
| LD05-S-9 | Olenyekskaya Channel - site 1 | 185 | 21,5 | 58,8 | 39 | 19,8 | **113** | |
| LD05-S-10 | Olenyekskaya Channel - site 1 | 77 | 18,1 | 51,4 | 20,8 | 30,6 | **1133** | |
| LD05-S-11 | Olenyekskaya Channel - site 1 | 354 | 22,3 | 55,9 | 27,8 | 28,1 | **511** | |
| LD05-S-12 | Olenyekskaya Channel - site 1 | 397 | 22,2 | 59,5 | 37,9 | 21,6 | **138** | duplicate |
| LD05-S-12 | Olenyekskaya Channel - site 1 | 397 | 22,2 | 63,7 | 39,1 | 24,6 | **146** | duplicate |
| LD05-S-13 | Olenyekskaya Channel - site 1 | 20 | 43,6 | 147 | 100 | 47 | **83** | |
| LD05-S-14 | Olenyekskaya Channel - site 1 | 1 | 43,6 | 145,8 | 96,8 | 49 | **92** | |
| LD05-S-15 | Tumatskaya Channel site | 77 | 18,1 | 53,2 | 33,5 | 19,7 | **128** | |
| LD05-S-16 | Tumatskaya Channel site | 354 | 22,3 | 59,2 | 43,8 | 15,4 | **72** | |
| LD05-S-17 | Tumatskaya Channel site | 22 | 44,9 | 118,3 | 76,1 | 42,2 | **135** | |
| LD05-S-18 | Tumatskaya Channel site | 22 | 44,9 | 129,9 | 88,9 | 41 | **93** | |
| LD05-S-19 | Tumatskaya Channel site | B5 | 43,9 | 111,8 | 82,3 | 29,5 | **77** | |
| LD05-S-20 | Tumatskaya Channel site | 22 | 44,9 | 178,3 | 106,6 | 71,7 | **116** | |
| LD05-S-21 | Tumatskaya Channel site | 1 | 43,6 | 124,3 | 101,9 | 22,4 | **38** | |
| LD05-S-22 | Tumatskaya Channel site | 14 | 44,1 | 113,5 | 86,6 | 26,9 | **63** | |
| LD05-S-23 | Tumatskaya Channel site | 77 | 18,1 | 56,3 | 41,7 | 14,6 | **62** | |
| LD05-S-24 | Tumatskaya Channel site | 20 | 43,6 | 130,1 | 98,4 | 31,7 | **58** | |

**Appendix 5-2:** Continuation

| Sample | Site | box no | inweight box [g] | box + sample (wet) [g] | box + sample (dry) ]g] | Ice content [g] | Ice content (%) to dry weight | remarks |
|---|---|---|---|---|---|---|---|---|
| LD05-S-25 | Tumatskaya Channel site | 185 | 21,5 | 67,2 | 49,8 | 17,4 | **61** | |
| LD05-S-26 | Olenyekskaya Channel – site 2 | 397 | 22,2 | 51,9 | 30 | 21,9 | **281** | |
| LD05-S-27 | Olenyekskaya Channel - site 2 | 1 | 43,6 | 117 | 64 | 53 | **260** | |
| LD05-S-28 | Sardakhsky Channel site | 354 | 22,3 | 82,8 | 65,1 | 17,7 | **41** | |
| LD05-S-29 | Sardakhsky Channel site | 185 | 21,5 | 51,9 | 37,2 | 14,7 | **94** | |
| LD05-S-30 | Sardakhsky Channel site | 20 | 43,6 | 98,1 | 71,6 | 26,5 | **95** | |
| LD05-S-31 | Sardakhsky Channel site | B5 | 43,9 | 94,9 | 70 | 24,9 | **95** | |
| LD05-S-32 | Sardakhsky Channel site | 14 | 44,1 | 118,6 | 74,9 | 43,7 | **142** | |
| LD05-S-33 | Sasyl Ary site | B5 | 43,9 | 121,4 | 77,5 | 43,9 | **131** | |
| LD05-S-34 | Sasyl Ary site | 20 | 43,6 | 160 | 137,8 | 22,2 | **24** | |
| LD05-S-35 | Kurungnakh site | 354 | 22,3 | 46,8 | 32,1 | 14,7 | **150** | |
| LD05-S-36 | Kurungnakh site | 185 | 21,5 | 52,9 | 37 | 15,9 | **103** | |
| LD05-S-37 | Kurungnakh site | 77 | 18,1 | 56 | 38,1 | 17,9 | **90** | |
| LD05-S-38 | Kurungnakh site | 20 | 43,6 | 121,9 | 79,2 | 42,7 | **120** | |
| LD05-S-39 | Arga Bylyr Areyta | 397 | 22,2 | 43,8 | 31,7 | 12,1 | **127** | |
| LD05-S-40 | Arga Bylyr Areyta | 14 | 44,1 | 112,4 | 56,6 | 55,8 | **446** | |
| LD05-S-41 | Arga Bylyr Areyta | 22 | 44,9 | 97,5 | 53,4 | 44,1 | **519** | |
| LD05-S-42 | Arga Bylyr Areyta | B5 | 43,9 | 92,6 | 59 | 33,6 | **223** | |
| LD05-S-43 | Tumatskaya Channel - Site 2 | 354 | 22,3 | 65,9 | 41,5 | 24,4 | **127** | |
| LD05-S-44 | Tumatskaya Channel - Site 2 | 185 | 21,5 | 54,3 | 44,7 | 9,6 | **41** | |
| LD05-S-45 | Tumatskaya Channel - Site 2 | 20 | 43,6 | 135,2 | 93,6 | 41,6 | **83** | |

## Appendix 5-3: List of water samples

| Nr | Sample | date | type | location | pH | Conductivity | Isotopes | Hydrochemistry | sampled by | packaging |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LD05-99/01 | 12.08.2005 | RW | Samoylov - house | 5,78 | 25 | X | X | hand | bottle |
| 2 | LD05-IW-1.30 | 14.08.2005 | RIW | Samoylov - site 1 | 6,37 | 50,8 | X | X | chain saw | bottle |
| 3 | LD05-IW-4.1 | 15.08.2005 | IW | Samoylov - site 2 | 6,76 | 65,3 | X | X | axe | bottle |
| 4 | LD05-IW-4.2 | 15.08.2005 | IW | Samoylov - site 2 | - | - | X | - | axe | bottle |
| 5 | LD05-IW-4.3 | 15.08.2005 | IW | Samoylov - site 2 | 7,69 | 68,6 | X | X | axe | bottle |
| 6 | LD05-IW-4.4 | 15.08.2005 | IW | Samoylov - site 2 | - | - | X | - | axe | bottle |
| 7 | LD05-IW-4.5 | 15.08.2005 | IW | Samoylov - site 2 | 7,76 | 98,3 | X | X | axe | bottle |
| 8 | LD05-TI-1 | 15.08.2005 | TI | Samoylov - site 2 | 7,29 | 76,2 | X | X | chain saw | bottle (=S7) |
| 9 | LD05-RI-1 | 15.08.2005 | RI | Samoylov - site 2 | 7,21 | 28,7 | X | X | axe | bottle |
| 10 | LD05-RI-2 | 15.08.2005 | RI | Samoylov - site 2 | - | - | X | - | axe | bottle |
| 11 | LD05-99/02 | 16.08.2005 | RW | Samoylov - house | - | - | X | - | hand | bottle |
| 12 | LD05-MI-1 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | 7,33 | 72,2 | X | X | chain saw | bottle |
| 13 | LD05-MI-2 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | - | - | X | - | chain saw | bottle |
| 14 | LD05-MI-3 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | 6,61 | 16,8 | X | X | chain saw | bottle |
| 15 | LD05-MI-4 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | 6,62 | 7,5 | X | - | axe | bottle |
| 16 | LD05-MI-5 | 17.08.2005 | MI | Olenyekskaya Channel - site 1 | 6,36 | 21,8 | X | X | axe | bottle |
| 17 | LD05-SW-1 | 17.08.2005 | SW | Olenyekskaya Channel | 7,12 | 111,9 | X | X | hand | bottle |
| 18 | LD05-SW-2 | 19.08.2005 | SW | Tumatskaya Channel | 7,3 | 124,1 | X | X | hand | bottle |
| 19 | LD05-99/03 | 21.08.2005 | RW | Samoylov | 6,25 | 21,4 | X | X | hand | bottle |
| 20 | LD05-SP-1 | 23.08.2005 | SP | Sardakhsky Channel site | 5,92 | 4,2 | X | X | chain saw | bottle |
| 21 | LD05-SW-3 | 23.08.2005 | SW | Sardakhsky Channel site | - | - | X | - | hand | bottle |
| 22 | LD05-SW-4 | 23.08.2005 | SW | Sardakhsky Channel | 7,04 | 113,5 | X | X | hand | bottle |
| 23 | LD05-RW-1 | 23.08.2005 | RW | Sardakhsky Channel site | - | - | X | - | hand | bottle |
| 24 | LD05-99/04 | 26.08.2005 | RW | Samoylov | 6,55 | 68 | X | X | hand | bottle |
| 25 | LD05-99/05 | 28.08.2005 | RW | Samoylov | 6,54 | 64,8 | X | X | hand | bottle |
| 26 | LD05-SW-5 | 28.08.2005 | SW | Banja Lake, Samoylov | 7,19 | 93,6 | X | X | hand | bottle |
| 27 | LD05-SW-6 | 28.08.2005 | SW | Lena, Samoylov | 7,19 | 142,2 | X | X | hand | bottle |
| 28 | LD05-99/06 | 29.08.2005 | RW | Samoylov | 6,9 | 12,3 | X | X | hand | bottle |
| 29 | LD05-99/07 | 30.08.2005 | RW | Samoylov | 6,39 | 15,1 | X | X | hand | bottle |
| 30 | LD05-MI-8 | 31.08.2005 | MI | Arga Bylyr Areyta | - | - | X | - | chain saw | bottle |
| 31 | LD05-MI-9 | 31.08.2005 | MI | Arga Bylyr Areyta | - | 10,4 | X | X | chain saw | bottle |
| 32 | LD05-MI-10 | 31.08.2005 | MI | Arga Bylyr Areyta | 7,83 | 167,5 | X | X | chain saw | bottle |
| 33 | LD05-MI-11 | 31.08.2005 | MI | Arga Bylyr Areyta | - | - | X | - | chain saw | bottle |
| 34 | LD05-MI-12 | 31.08.2005 | MI | Arga Bylyr Areyta | 7,13 | 6,1 | X | X | chain saw | bottle |
| 35 | LD05-SW-7 | 01.09.2005 | SW | Samoylov | 7,6 | 143,5 | X | X | hand | bottle |

# 6. Report on hydrological work in the Lena River Delta in August 2005

*Irina Fedorova, Dmitry Bolshiyanov, Dmitry Nikels, Aleksander Makarov*

## 6.1 Introduction

Hydrological measurements were carried out during the expedition to the Lena Delta in the summer of 2005. They were a continuation of previous investigations of the hydrological, hydrodynamic, and bed-deformation processes in the main Channels and representative points of the Lena River Delta.

This study was part of the "Laptev Sea System" project and supported by a grant of Russian Foundation for Basic Research: No. 05-05-64419-02 "Hydromorphogenesis of the Lena River Delta".

Measurements were made using a ship (the Neptun) of the hydrological station and a small motorboat.

The investigation can be divided into four primary parts:

1. Study at a daily station in the Olenekskaya Channel mouth.
2. Study along the Olenekskaya Channel from its mouth to the Bulkurskaya branch.
3. Study around Sardakh Island: on the Sardakhskaya and Bolshaya Trofimovskaya Channels.
4. Study of the main Channels of the Lena River delta: Bykovskaya, Trofimovskaya, Tumatskaya, Main bed, Olenekskaya.

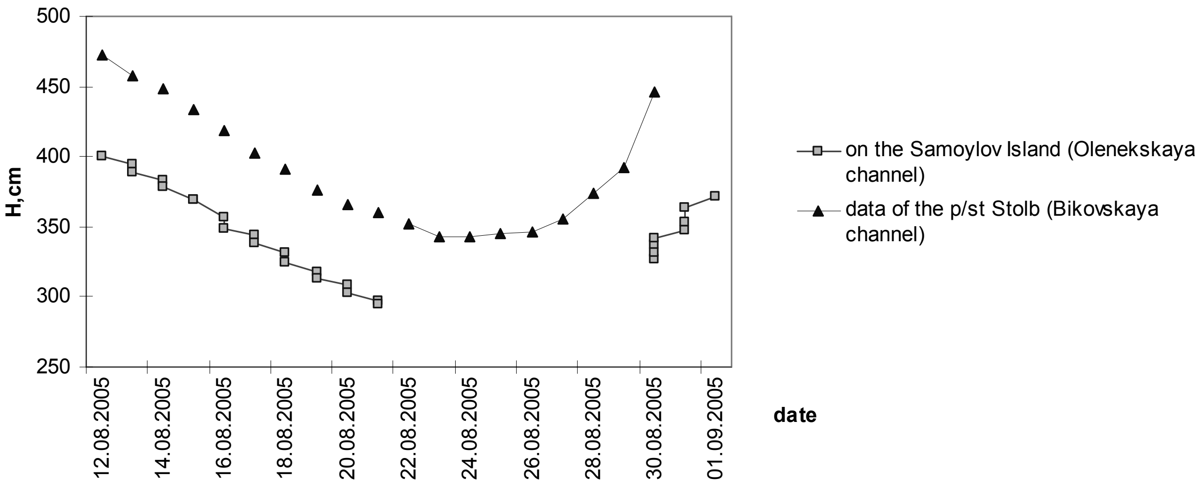


**Figure 6-1:** Olenekskaya and Bykovskaya Channels' water level in August 2005

Fifteen discharge gauging profiles were measured during August 2005. Their location is shown in Table 6-1.

**Table 6-1:** The hydrological gauging profile locations

| Profile Number | Sampling Location | Date | Maximal depth [m] | Longitude, N | Latitude, E |
|---|---|---|---|---|---|
| Profile 1 | Olenekskaya Ch., daily station | 15.08.05, 16.08.05, 17.08.05 | 22,7 | 72°52’48,3” | 127°12’53,6” |
| Profile 2 | Angardam Ch. | 18.08.05 | 16,5 | 72°45’25,4” | 123°38’54,1” |
| Profile 3 | Olenekskaya Ch. | 19.08.05 | 6,6 | 72°39’25,2” | 124°20’20,8” |
| Profile 4 | Olenekskaya Ch. | 19.08.05 | 8,3 | 72°30’20,9” | 125°17’10,4” |
| Profile 5 | Olenekskaya Ch. | 20.08.05 | 17,8 | 72°21’32,4” | 125°40’16,2” |
| Profile 6 | Olenekskaya Ch., hydrometrical gauge line | 20.08.05 | 9,2 | 72°17’46,1” | 126°05’40,0” |
| Profile 7 | Bulkurskaya Ch. | 20.08.05 | 7,3 | 72°13’57,7” | 126°06’18,5” |
| Profile 8 | Sardahskaya Ch. | 23.08.05 | 27,8 | 72°34’50,0” | 127°11’55,4” |
| Profile 9 | Trofimovskaya Ch. | 23.08.05 | 22 | 72°36’52,5” | 127°15’30,0” |
| Profile 10 | Bykovskaya Ch., hydrometrical gauge line | 24.08.05 | 12,5 | 72°24’28,0” | 126°54’47,9” |
| Profile 11 | Main Ch. of the Lena River, hydrometrical gauge line | 25.08.05 | 34,9 | | |
| Profile 12 | Trofimovskaya Ch., hydrometrical gauge line | 25.08.05 | 13,3 | | |
| Profile 13 | Tumatskaya Ch., hydrometrical gauge line | 27.08.05 | 12,6 | 72°25’06,4” | 126°27’23,6” |
| Profile 14 | Sardahskaya Ch. | 24.08.05 | 24,1 | 72°38’18,8” | 127°51’41,2” |
| Profile 15 | Sardahskaya Ch. | 25.08.05 | 19,8 | 72°30’53,7” | 128°29’11,5” |

The following measurements were conducted:

- Levelling of a temporary sectional staff gauge on the Olenekskaya Channel.
- Water level measurements on the Olenekskaya Channel gauges (one of them located in the channel mouth, and the second on Samoylov Island, Figure 6-1).
- Water discharge and suspended sediment supply observations at the daily station during different stages of surge.
- Water discharge and suspended sediment supply observations at the main and secondary channels of the Lena delta.
- Coring of lacustrine surface sediment from three lakes of the delta’s 1$^{st}$ terrace (Table 6-2).
- Water, solid and suspended particulate materials (SPM) sampling for hydrochemical, geochemical, total and organic carbon content (TOC/TC), and grain-size. Isotopes were analyzed for samples from the delta’s channels, lakes, a stream, and a sea bay.
- Preliminary hydrochemical analysis and runoff calculation in the field.

**Table 6-2:** Location of the lakes where sediment cores were taken in August 2005 (Ch. = Channel)

| № | Lake Name/Number | Date | Core length [cm] | Comments | Location | |
|---|---|---|---|---|---|---|
| | | | | | Longitude, N | Latitude, E |
| 1 | Lake "Schakhtnoye" | 20.08.05 | 53 | 1st terrace | 72°20'43,1" | 125°40'09,5" |
| 2 | Lake №1 on Chay-Aryi Island | 24.08.05 | Surface | 1st terrace | Chay-Aryi Island | |
| 3 | Lake №2 on Chay-Aryi Island | 31.08.05 | 17 | 1st terrace | Chay-Aryi Island | |

## 6.2 Methods

All gauge lines were located in representative channel stretches. Location was measured using GPS. Depth measurements were made with an echo-sounding device (Garmin) from a motorboat and made at one-meter intervals in both channel branches. At characteristic bed relief points some measuring verticals were fixed. There were usually 4 to 7 verticals per profile. Observations were made for five horizons at each vertical: surface; 0,2H; 0,6H; 0,8H, and bottom (where H is the water depth at the vertical). There were four main values for observations: water velocity, water sampling, temperature, and depth measurement. Water velocity values were used for water discharge calculation. Water velocity was measured using a hydrological water speed indicator (GR-21). Water was sampled for hydrochemical analyses and filtered for turbidity measurement (and suspended sediment supply), geochemical and TOC/TC analyses. Water was sampled using a vacuum bathometer at a specific water depth (Table 6-3). And filtered through 10 cm diameter paper filters on a Kuprina device. Then turbidity and water discharge were combined to calculate suspended materials supply. For geochemical analysis of suspended particulate matter (SPM) and for TOC/TC, polycarbonate (PC)and cellulose acetate filters (GF), respectively, with diameters of 4.5 cm were used. Sampling locations are listed in Table 6-4. All filters were dried and weighed at the Otto Schmidt Laboratory in the Arctic and Antarctic Research Institute (AARI), where some of the analyses are planned. Most of the analyses will occur at the AWI (Potsdam) laboratory.

Water temperature and water depth were measured using an echo-sounding device.

Past geochemical conditions of the investigated area are studied by means of lacustrine surface sediment core analyses. Cores were taken using the GOIN tube corer. A core taken from Lake Shakhtnoye core was separated into 16 layers differing in their sediment structure (Table 6-5). Cores from two lakes of the 1st terrace on Chay-Ary Island will also be analyzed. One of the cores contained surface sediments (lake 1); the other was divided into 6 sediment layers. The possibility of precipitation and accumulation of different types of material in bottom sediments will be investigated using the collected bed samples (Table 6-5).

**Table 6-3:** List of water samples and planned analyses (Ch. = Channel)

| Sample No | Sample location | Date | Depth, [m] | Longitude, N | Latitude, E | Eh, [µS/см] | Hydrochemistry | Isotope analyses |
|---|---|---|---|---|---|---|---|---|
| 1.1 | Olenekskaya Ch., Profile 1 | 15.08.05 | 17,76 | 72°52'48,3" | 127°12'53,6" | 115,4 | + | + |
| 1.2 | Olenekskaya Ch., Profile 1 | 15.08.05 | 4,44 | 72°52'48,3" | 127°12'53,6" | 105,6 | + | + |
| 1.3 | Olenekskaya Ch., Profile 1 | 16.08.05 | 19,96 | 72°52'48,3" | 127°12'53,6" | 103,6 | + | + |
| 1.4 | Olenekskaya Ch., Profile 1 | 16.08.05 | 4,24 | 72°52'48,3" | 127°12'53,6" | 125,3 | + | + |
| 1.5 | Olenekskaya Ch., Profile 1 | 17.08.05 | 17,44 | 72°52'48,3" | 127°12'53,6" | 110 | + | + |
| 1.6 | Olenekskaya Ch., Profile 1 | 17.08.05 | 4,36 | 72°52'48,3" | 127°12'53,6" | 109,1 | + | + |
| 1.7 | Kuba Bay | 17.08.05 | surface | | | 24,5 mS/cm | + | + |
| 1.8 | Lagoon lake nearby the Kuba Bay | 17.08.05 | surface | | | 2,24 mS/cm | + | + |
| 1.9 | Angardam Ch., Profile 2 | 18.08.05 | 12 | 72°45'25,4" | 123°38'54,1" | 107 | + | + |
| 1.10 | Angardam Ch., Profile 2 | 18.08.05 | 9 | 72°45'25,4" | 123°38'54,1" | 117 | + | + |
| 1.11 | Angardam Ch., Profile 2 | 18.08.05 | 3 | 72°45'25,4" | 123°38'54,1" | 108 | + | + |
| 1.12 | Tas-yuryage River | 18.08.05 | surface | | | 88 | + | + |
| 1.13 | Olenekskaya Ch., Profile 3 | 19.08.05 | 5,12 | 72°39'25,2" | 124°20'20,8" | 108,9 | + | + |
| 1.14 | Olenekskaya Ch., Profile 3 | 19.08.05 | 1,28 | 72°39'25,2" | 124°20'20,8" | 108,7 | + | + |
| 1.15 | Lake 1 on the 1st terrace | 19.08.05 | surface | 72°35'08,3" | 124°56'28,7" | 104,1 | + | + |
| 1.16 | Olenekskaya Ch., Profile 4 | 19.08.05 | 6,48 | 72°30'20,9" | 125°17'10,4" | 113 | + | + |
| 1.17 | Olenekskaya Ch., Profile 4 | 19.08.05 | 1,62 | 72°30'20,9" | 125°17'10,4" | 115,1 | + | + |
| 1.18 | Olenekskaya Ch., Profile 5 | 20.08.05 | 14,24 | 72°21'32,4" | 125°40'16,2" | 118,5 | + | + |
| 1.19 | Olenekskaya Ch., Profile 5 | 20.08.05 | 3,56 | 72°21'32,4" | 125°40'16,2" | 117,5 | + | + |
| 1.20 | Lake "Shakhtnoye" on the 1st terrace | 20.08.05 | surface | 72°20'43,1" | 125°40'09,5" | 81,7 | + | + |
| 1.21 | Olenekskaya Ch., Profile 6 | 20.08.05 | 1,82 | 72°17'46,1" | 126°05'40,0" | 139,7 | + | + |
| 1.22 | Olenekskaya Ch., Profile 6 | 20.08.05 | 7,24 | 72°17'46,1" | 126°05'40,0" | 139,4 | + | + |
| 1.23 | Bulkurskaya Ch., Profile 7 | 20.08.05 | 4,32 | 72°13'57,7" | 126°06'18,5" | 103 | + | + |
| 1.24 | Sardahskaya Ch., Profile 8 | 23.08.05 | surface | 72°34'50,0" | 127°11'55,4" | 105,2 | + | + |
| 1.25 | Sardahskaya Ch., Profile 14 | 24.08.05 | 6,36 | 72°38'18,8" | 127°51'41,2" | 109,3 | + | + |
| 1.26 | Sardahskaya Ch., Profile 15 | 25.08.05 | 14,88 | 72°30'53,7" | 128°29'11,5" | 111,4 | + | + |
| 1.27 | Trofimovskaya Ch., Profile 9 | 23.08.05 | surface | 72°36'52,5" | 127°15'30,0" | 107,7 | + | + |
| 1.28 | Bikovskaya Ch., Profile 10 | 24.08.05 | 2,40 | 72°24'28,0" | 126°54'47,9" | 110,5 | + | + |
| 1.29 | Bykovskaya Ch., Profile 10 | 24.08.05 | 9,60 | 72°24'28,0" | 126°54'47,9" | 110 | + | + |
| 1.30 | Main Channel of the Lena River, Profile 11 | 25.08.05 | 18,90 | | | 118,7 | + | + |
| 1.31 | Trofimovskaya Ch., Profile 12 | 25.08.05 | 2,56 | | | 129,9 | + | + |
| 1.32 | Tumatskaya Ch., Profile 13 | 27.08.05 | 2,54 | 72°25'06,4" | 126°27'23,6" | 135,7 | + | + |
| 1.33 | Lake 2 on the Chay-Ari Island | 31.08.05 | surface | | | 111 | + | + |
| 1.34 | Ice from Olenekskaya Ch. | 17.08.05 | inside | 72°52'48,3" | 127°12'53,6" | | | + |

**Table 6-4.** List of SPM samples, the Lena Delta, 2005

| № | Number of **PC** filters | Number of **GF** filters | Sampling Location | TOC | TC | Geochemistry |
|---|---|---|---|---|---|---|
| 1 | | GF 1 | Profile 15 | + | + | |
| 2 | | GF 2 | Profile 14 | + | + | |
| 3 | | GF 13 | Profile 11 | + | + | |
| 4 | | GF 15 | Profile 3 | + | + | |
| 5 | | GF 16 | Profile 6 | + | + | |
| 6 | | GF 17 | Profile 2 | + | + | |
| 7 | | GF 18 | Profile 3 | + | + | |
| 8 | | GF 19 | Profile 4 | + | + | |
| 9 | | GF 20 | Profile 10 | + | + | |
| 10 | | GF 49 | Profile 1, 17.08.05 | + | + | |
| 11 | | GF 50 | Profile 13 | + | + | |
| 12 | | GF 51 | Profile 8 | + | + | |
| 13 | | GF 52 | Profile 1, 16.08.05 | + | + | |
| 14 | | GF 53 | Profile 13 | + | + | |
| 15 | | GF 54 | Profile 10 | + | + | |
| 16 | | GF 55 | Profile 5 | + | + | |
| 17 | | GF 56 | Profile 9 | + | + | |
| 18 | | GF 57 | Profile 7 | + | + | |
| 19 | | GF 58 | Profile 12 | + | + | |
| 20 | | GF 59 | Profile 1, 15.08.05 | + | + | |
| 21 | | GF 60 | Profile 6 | + | + | |
| 22 | | GF 86 | Profile 12 | + | + | |
| | | | | | | |
| 23 | PC 1 | | Profile 14 | | | + |
| 24 | PC 2 | | Profile 6 | | | + |
| 25 | PC 161 | | Profile 12 | | | + |
| 26 | PC 162 | | Profile 8 | | | + |
| 27 | PC 163 | | Profile 5 | | | + |
| 28 | PC 164 | | Profile 1, 15.08.05 | | | + |
| 29 | PC 170 | | Profile 2 | | | + |
| 30 | PC 171 | | Profile 4 | | | + |
| 31 | PC 172 | | Profile 5 | | | + |
| 32 | PC 173 | | Profile 3 | | | + |
| 33 | PC 174 | | Profile 4 | | | + |
| 34 | PC 177 | | Profile 7 | | | + |
| 35 | PC 178 | | Profile 1, 16.08.05 | | | + |
| 36 | PC 179 | | Profile 11 | | | + |
| 37 | PC 180 | | Profile 13 | | | + |
| 38 | PC 206 | | Profile 15 | | | + |
| 39 | PC 213 | | Profile 1, 16.08.05 | | | + |
| 40 | PC 214 | | Profile 1, 17.08.05 | | | + |
| 41 | PC 215 | | Profile 1, 15.08.05 | | | + |
| 42 | PC 216 | | Profile 9 | | | + |
| 43 | PC 218 | | Profile 10 | | | + |

**Table 6-5**. List of lacustrine sediment cores and bed-samples from the Lena River Delta Channels 2005 and analyses that are planed to be observed

| № | Lake | Layer of the cores | TOC | TC | Geo-chemistry | Grain-size |
|---|---|---|---|---|---|---|
| 1 | Lake “Shakhtnoye” on the 1st terrace N 72°20’43,1”; E 125°40’09,5” 20.08.05 | 0-2 | + | + | + | + |
| 2 | | 2-5 | + | + | + | + |
| 3 | | 5-8 | + | + | + | + |
| 4 | | 8-12 | + | + | + | + |
| 5 | | 12-15 | + | + | + | + |
| 6 | | 15-20 | + | + | + | + |
| 7 | | 20-25 | + | + | + | + |
| 8 | | 25-27 | + | + | + | + |
| 9 | | 27-30 | + | + | + | + |
| 10 | | 30-33 | + | + | + | + |
| 11 | | 33-36 | + | + | + | + |
| 12 | | 36-38 | + | + | + | + |
| 13 | | 38-42 | + | + | + | + |
| 14 | | 42-45 | + | + | + | + |
| 15 | | 45-49 | + | + | + | + |
| 16 | | 49-53 | + | + | + | + |
| 17 | Lake № 1 on Chay-Ary Island on the 1st terrace 24.08.05 Surface of sediments | top | + | + | + | + |
| 18 | | bottom | + | + | + | + |
| 19 | Lake № 2 on Chay-Ary Island on the 1st terrace 31.08.05 | 0-2 | + | + | + | + |
| 20 | | 2-4 | + | + | + | + |
| 21 | | 4-7 | + | + | + | + |
| 22 | | 7-10 | + | + | + | + |
| 23 | | 10-14 | + | + | + | + |
| 24 | | 14-17 | + | + | + | + |
| 25 | Tumatskaya Ch. left bank | bottom | + | + | + ? | + |
| 26 | Main Ch. Ch. | bottom | + | + | + ? | + |
| 27 | Olenekskaya Ch. | bottom | + | + | + ? | + |
| 28 | Trofimovskaya Ch. | bottom | + | + | + ? | + |
| 29 | Tumatskaya Ch. right bank | bottom | + | + | + ? | + |
| 30 | Bulkurskaya Ch. | bottom | + | + | + ? | + |
| 31 | Trofimovskaya Ch. | bottom | + | + | + ? | + |
| 32 | Angardam Ch. | bottom | + | + | + ? | + |

## 6.3 Preliminary results

Water discharge and suspended material supply measured at the gauging profiles are shown in Fig. 6-2 and 6-3 and in Table 6. The main channelscontribute decreasing amounts of discharge in the order: Trofimovskaya Channel, Bykovskaya, Olenekskaya, and the minor one is Tumatskaya. After Sardakh Island, water is mainly transported into the Sardahskaya Channel. Discharge decreases towards the channel mouth (the gauging station near Sobo-Sise Island) due to the hydraulic head of seawater. The same situation was noticed for the Olenekskaya Channel estuary. Tumatskaya Channel has contributed very little discharge for the three-year period of observation in the delta. Extinction of this branch could therefore be a possibility.

Investigations of the Angardam Channel have shown an increase of erosion in this branch. Complementary measurements in this area are required to clarify the responsible processes and rate of change.

Twice-daily investigations in the Olenekskaya Channel revealed an abnormal correlation between minimum water velocity and maximum turbidity. We suggest that seawater influx into the channels is responsible. The observed high turbidity would then correspond to coagulation and flocculation processes.

Comparison of water turbidity and velocity distribution in horizontal and vertical sections of the gauging station do not demonstrate a consistent correlation. If water speed depends on bed morphology, then turbidity reflects the hydraulic character of the river channel.

The visual character of the sediment cores (availability of different layers) suggests rapid changes in environmental conditions in the Lena Delta. Geochemical, granulometrical and other analyses will provide more information.

## 6.4 Conclusion

In August 2005 hydrological field measurements were carried out to extend previous investigations and included standard hydrometrical measurements, confirmation of previous results, and collecting new information.

Some areas of intensive erosion in the delta had been observed before, and this field campaign added extra information and observation points: these are the Sardakhsko-Trofimovskiy, Bulkursko-Olenekskiy, and Oleneksko-Angardamskiy junctions. Sea level fluctuation and run-off have an increasing influence on water redistribution between channels and on the intensity of erosion processes in riverbeds. Trends in bed transformation in the Lena delta were measured.

Hydrological observations in channel mouths and on the Angardam Branch were done for the first time in the Lena delta.

Lacustrine surface sediment cores as well as geochemical records of the paleo- and current environment of the delta were collected.

In addition, other areas of the delta, such as the Tumatskaya Channel, were chosen for further study. Palaeo-hydrological reconstruction demands special knowledge and subsidiary expedition measurements.

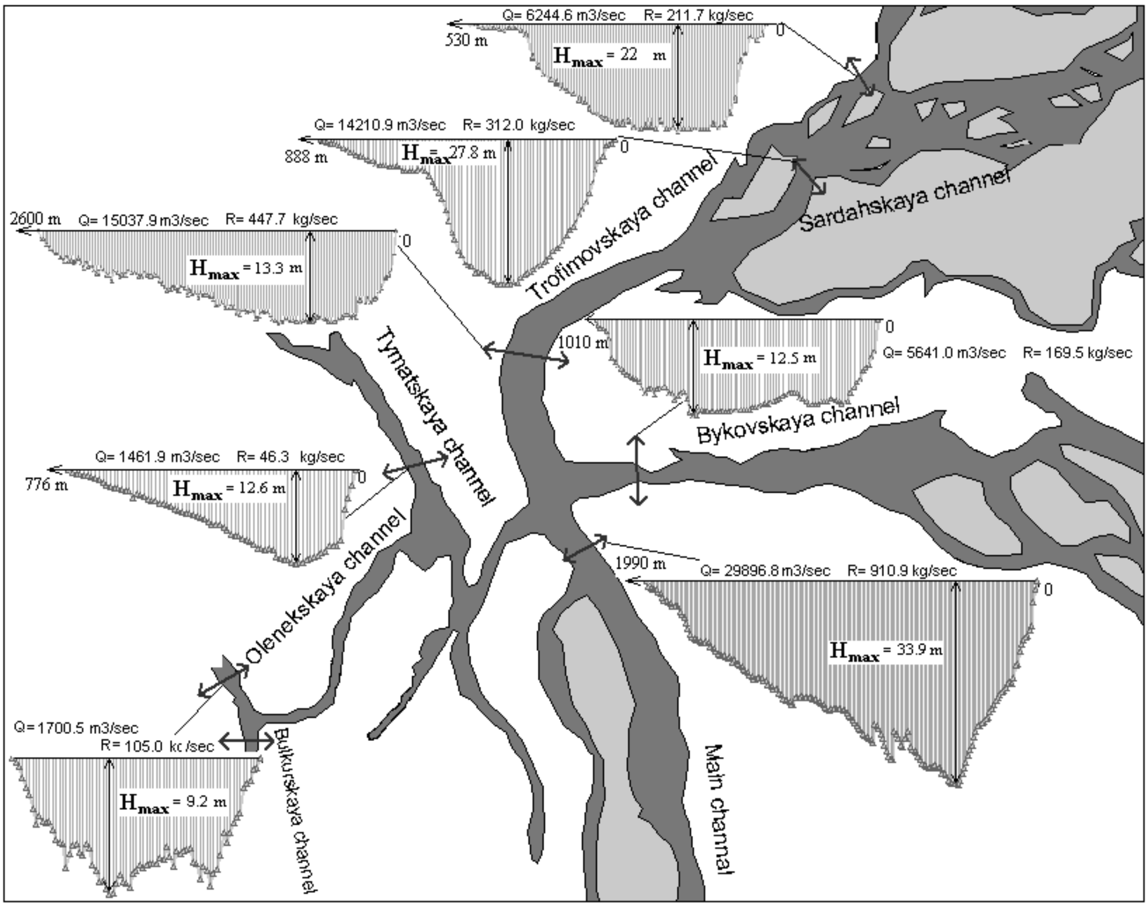


**Figure 6-2:** Water discharge and suspended supply of main channels of the Lena River Delta

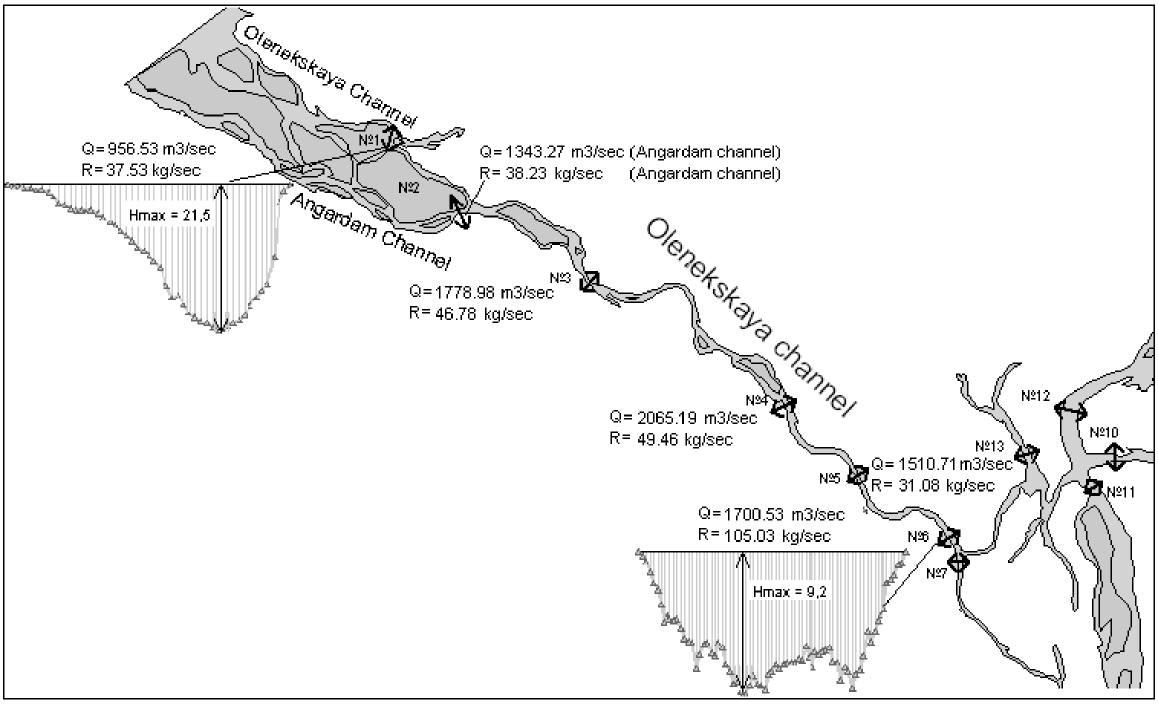


**Figure 6-3**: Water discharge and suspended supply at the gauging stations of the Olenekskaya and Angardam Channels.

**Table 6-6:** Measured water discharge and suspended sediment supply of gauging stations on the main channels of the Lena Delta, August 2005

| Gauging Station No | Name of Channel | Water discharge Q, $m^3/s$ | Suspended supply R, kg/s | Date | Gauging station location |
|---|---|---|---|---|---|
| 1 | Olenekskaya Ch., daily station | 882.3 | 15.5 | 15.08.05 | Daily station near p. Nagym |
| | | 1380.9 | 22.0 | 16.08.05 | |
| | | 922.3 | 36.2 | 17.08.05 | |
| 2 | Angardam Ch. | 1336.9 | 38.1 | 18.08.05 | 2 km from the Olenekskaya Ch. |
| 3 | Olenekskaya Ch. | 1810.3 | 59.5 | 19.08.05 | |
| 4 | Olenekskaya Ch. | 2010.0 | 47.2 | 19.08.05 | Near Gusinka River |
| 5 | Olenekskaya Ch. | 1511.5 | 30.4 | 20.08.05 | Near p. Chay-Tumus |
| 6 | Olenekskaya Ch., hydrometrical gauge line | 1692.7 | 36.2 | 20.08.05 | Main hydrometrical gauging station |
| 7 | Bulkurskaya Ch. | 106.3 | 0.42 | 20.08.05 | 2 km before to the Olenekskaya Ch. flowing |
| 8 | Sardahskaya Ch. | 14210,9 | 312,1 | 23.08.05 | Near Sardah Island |
| 9 | Trofimovskaya Ch. | 6244.6 | 211.7 | 23.08.05 | Near Gogolevskiy Island |
| 10 | Bikovskaya Ch., hydrometrical gauge line | 5641.0 | 169.5 | 24.08.05 | Main hydrometrical gauge line |
| 11 | Main Ch. of the Lena River, hydrometrical gauge line | 29896.9 | 911.0 | 25.08.05 | Main hydrometrical gauge line, 4.7 km from Stolb Island |
| 12 | Trofimovskaya Ch., hydrometrical gauge line | 15037.9 | 447.7 | 25.08.05 | Main hydrometrical gauging station |
| 13 | Tumatskaya Ch., hydrometrical gauge line | 1461.9 | 46.3 | 27.08.05 | Main hydrometrical gauging station |
| 14 | Sardahskaya Ch. | 6811,5 | 171,7 | 24.08.05 | Near Bur-Kuopput Island |
| 15 | Sardahskaya Ch. | 4334,3 | 102,8 | 25.08.05 | Near Sobo-Sise Island, 30 km from a mouth of channel |